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NBS Special Publication 722

A User's Guide for RAPID, Reduction Algorithms for the Presentation of Incremental Fire Data

Breese and Peacock

National Bureau of Standards

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[1] Headquarters and Laboratories at Gaithersburg, MD, unless otherwise noted; mailing address Gaithersburg, MD 20899

[2] Some divisions within the center are located at Boulder, CO 80303.

[3] Located at Boulder, CO, with some elements at Gaithersburg, MD.

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Gaithersburg, MD 20899

August 1986

U.S. Department of Commerce
Malcolm Baldrige, Secretary

National Bureau of Standards
Ernest Ambler, Director

Library of Congress
Catalog Card Number: 86-600565
National Bureau of Standards
Special Publication 722
Natl. Bur. Stand. (U.S.),
Spec. Publ. 722
195 pages (Aug. 1986)
CODEN: XNBSAV

U.S. Government Printing Office
Washington: 1986

For sale by the Superintendent
of Documents,
U.S. Government Printing Office,
Washington DC 20402

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Note: Certain commercial equipment is identified in this paper in order to illustrate adequately certain device specific characteristics. Such identification does not imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the equipment is necessarily the best available for the purpose.

A Users Guide for RAPID,

Reduction Algorithms for the Presentation of Incremental Fire Data

Version 86.0602

J. Newton Breese and Richard D. Peacock

Abstract

The voluminous amount of data that can be collected by automatic data acquisition systems during large scale fire tests requires the use of a digital computer for the reduction of data. RAPID is a stand-alone program specifically designed to convert raw instrument voltages collected during such tests into meaningful units. The reduced data can also be used alone or in combinations to obtain quantities that require more than minimal data reduction. The program is written with the ability to accept data from a user defined data acquisition system, with the ability to check the correctness of data included. Through the use of input data provided by the user, the data can be converted into meaningful scientific units. The data can then be presented in tabular or printer plot form, or stored for further processing.

This user's guide provides detailed instructions for the use of the program.

Key Words: Computer program; data acquisition; data reduction; fire tests

1. INTRODUCTION

In 1968, the Building Research Division of the National Bureau of Standards (NBS) approached the Computer Services Division of NBS with a proposal concerning the design of a series of computer programs to facilitate the analysis of automatically recorded data. During the following two years, a system of programs called SPEED (**S**ystematic **P**lotting and **E**valuation of **E**numerated **D**ata) was developed and tested. This system was announced at the

Ninth Annual Technical Symposium of the Association for Computing Machinery and in an article in Computer Graphics. The following paragraphs, quoted from the Computer Graphics article, which indicated the need for SPEED are still valid:

> "The use of digital scanning systems offers several advantages to the research scientist. First, their rapid recording capabilities allow for more complete data sampling. Second, automatically recorded data is more accurate than data that has been recorded manually.
>
> These advantages are however, to some extent, counterbalanced by several problems which arise. Two problems are caused by the large volume of recorded data. First, it is difficult, if not impossible, to process large volumes of data by hand. Thus, the scientist finds it necessary to make use of the computer. Unfortunately, he is often unfamiliar with the capabilities and limitations of this device. Second, when presented with a large volume of data, it is often difficult for the scientist to rapidly interpret the broad characteristics of general trends that may be present. Two other problems arise in the form in which the data are recorded. The data are generally recorded in millivolts rather than standard units. Thus some conversion process, usually a linear transformation, is required. Furthermore, the recorded data are not usually directly compatible with computers. In order for a computer to read this data some special computer program must be used to read this data in the recorded form and translate it into the internal computer representation."[1]

During the years since its announcement, SPEED has been widely used at NBS and other computer installations and has been rewritten once to provide new features and a standardized system of programs with current documentation[2]. RAPID (**R**eduction **A**lgorithms for the **P**resentation of **I**ncremental Fire **D**ata) is

---

[1] Smith, John M., Automatic Data Evaluation, Manipulation, Display, and Plotting with SPEED, Computer Graphics, Vol. 4, No. 2, 41-53 (Fall 1970).

[2] Peacock, R. D., and Smith, John M., SPEED2, A Computer Program for the Reduction of Data from Automatic Data Acquisition Systems, Natl. Bur. Stand. (U. S.), NBSTN 1108 (September 1979).

a stand-alone program that employs the software developed for the PLOT2 phase of SPEED2. In addition, it has been expanded and designed specifically designed to convert raw fire test data into meaningful units. The reduced data can be used alone or in combinations to obtain quantities that require more than minimal data reduction.

This report provides detailed instructions for the use of the program and describes the implementation of the various calculations available.

2. Part A: Input and Output Control

PART A

Input	Variables	Format	Comments
A1	INTYPE,INPRT,INPNCH, INSTOP,INERR,INSKIP, INSAVE,INTEST	8I5	This input contains parameters which control the input. The various possibilities and their meanings are: INTYPE = 0 - read Part C data inputs to specify a special data acquisition system 1 - reduced data format input images 2 - pre-processed raw data input images in reduced data format (see INSAVE) 3 - VIDAR 5400 series input image format 4 - VIDAR 5400 series magnetic tape format [not available in this version] 5 - Hewlett-Packard 9836 input image format 6 - Hewlett-Packard 9836 magnetic tape format [not available in this version] 7 - VIDAR Autodata 10 series input image format [not available in this version] 8 - VIDAR Autodata 10 series magnetic tape format [not available in this version] 9 - VIDAR Autodata 9 series input image format 10 - VIDAR Autodata 9 series magnetic tape format [not available in this version]

INPRT - Directs printing of data as recorded by a data acquisition system. If INPRT is equal to zero, no data is printed. If INPRT is greater than zero, INPRT specifies the maximum number of data records to be printed. If INPRT is equal to -1, all data records are printed. If INPRT is equal to -2, only data records that contain errors are printed.

INPNCH - Directs the output of the data as recorded by a data acquisition system to secondary storage. If INPNCH is greater than zero, all data records are written to the unit specified by INPNCH. The user may assign this unit to any storage media.

INSTOP - If INSTOP is non-zero, directs RAPID to stop execution after processing the input data recorded by the data acquisition system.

INERR - Specifies the maximum number of error messages to be printed during processing of data recorded by a data acquisition system.

INSKIP - If INSKIP is non-zero, read Part D data inputs to specify records of input data to be skipped.

			INSAVE - Directs the output of interpreted raw data to mass storage, magnetic tape, etc. If INSAVE is greater than zero, all data records not skipped (see INSKIP) are written to the unit specified by INSAVE. The user may assign this unit to any storage media. This "formatted raw data" may be identified and used as input to subsequent runs by setting INTYPE equal to 2. The format of the raw data saved is the same as any reduced data saved by setting NPNCH greater than zero (see input A2 below). See NPDI [4]. INTEST - See NPDI [5] = 0 - include the test number (if it exists) on input < 0 - delete the test number (if it exists) on input

Input	Variables	Format	Comments
A2	NTEST,NPRT,NPNCH, NPLOT,NCORR,NERR	6I5	This input contains certain parameters which control actions concerning the transformed data matrix. The possibilities are: NTEST - See NPDI [5] - between 1 and 999, inclusive - specifies a test number to be prefixed to reduced data instrument numbers output by setting NPNCH greater than zero. = 0 - on saved output (see NPNCH) only include the test number if it already exists (from input).

			NPRT - See NPDI [6] > 0 - print out the transformed data matrix and summary of minima, maxima, and averages < 0 - print out only the summary = 0 - no printout NPNCH - Directs the output of the transformed data matrix to card punch, mass storage, or magnetic tape. If NPNCH is greater than zero, all data records are written to the unit specified by NPNCH. The user may assign this unit to any storage media. NPLOT - If NPLOT is non-zero, Part I data inputs are read to generate printer plots of selected instruments. NCORR - If NCORR is non-zero, Part G data inputs are read to correct readings of the data matrix. NERR - Specifies the maximum number of error messages to be generated by any one data reduction subroutine.

3. Part B: Test and Instrument Descriptions

Input	Variables	Format	Comments
B1,B2	TITLE(1:80),TITLE (81:120)	A80/ A40	These two inputs specify the title of the experiment, printed at the top of all pages of output.

Input	Variables	Format	Comments
B3	KH(i),ITYPE(i), NAME(i),KHPRT(i)	I6,I2, A66,A3	For each instrument included in the data matrix, there must be a input of this form defining the instrument number, KH(i); the instrument type, ITYPE(i); and the instrument name, NAME(i). The instrument number, KH(i), is either the channel number assigned by the data acquisition system, or, for user created instruments, a unique number assigned by the user. NAME(i) is broken into two parts: a 6-character abbreviated ID that is printed when listing or plotting data and a 60-character description. If KHPRT is non-blank, the transformed instrument values will NOT be printed. Note that all the channels may be skipped by setting NPRT <= 0 on PLOT2 Data Input A2. The number of inputs is variable, with the end signalled by a input B4, below.

Input	Variables	Format	Comments
B4	IEND	77X,A3	If IEND is equal to 999, this input signals the end of the set of instrument defining inputs, B3 above.

Input	Variables	Format	Comments
B5	C(i),ADD(i),POWER(i)	1X, 3F15.6	Each C(i), ADD(i), and POWER(i) represent the conversion coefficients for all instruments of type i. There are as many B5 inputs as there are different types of instruments as defined in the set of instrument inputs, B3 above. (See NPDI [7]).
Input	Variables	Format	Comments
B6	IEND	77X,A3	If IEND is equal to 999, this input signals the end of the set of conversion coefficient inputs, B5 above.

4. Part C: Input Formats for Data Acquisition Systems Not Pre-Defined in RAPID

If the data acquisition system is not one of the pre-defined types (see Table 1), the user may have to define the formats the program will need for the input media, the time and data readings, and the end-of-file marker.

At this time, there is only one format for specifying the input media. The syntax for the format is below:

INPUT=DATA IMAGES, CHANNELS PER LINE=<n>

where n is any integer number >= 1 and where the number is the maximum number of channels found on a single input image.

As is noted, the format is a specification for data images. Data added from mass storage or tape files, and data transferred from remote terminals are considered DATA IMAGES.

The syntax for defining the data readings, time readings, and end-of-record and end-of-file markers is the same for all four:

READING=<pattern> or
TIME=<pattern> or
EOR=<pattern> or
EOR=EOR or
EOF=<pattern> or
EOF=EOF

where pattern is defined by

$$[N_1]*(C_1)[N_2]*(C_2)[N_3]*(C_3) \ldots [N_{m-2}]*(C_{m-2})[N_{m-1}]*(C_{m-1})[N_m]*(C_m)$$

and

$N_1, N_2, N_3 \ldots Nm\text{-}2, Nm\text{-}1, N_m$ = any integer greater than or equal to 1.

$C_1, C_2, C_3 \ldots Cm\text{-}2, Cm\text{-}1, C_m$ = one or more of the following character specifications:

S - the seconds portion of the time reading
M - the minutes portion of the time reading
H - the hours portion of the time reading
D - the days portion of the time reading
N - any numeric digit (0-9)
A - any alphanumeric character
C - a channel number digit
+<char> - the character <char> used to identify a positive reading
-<char> - the character <char> used to identify a negative reading
V - a numeric digit of the value of the instrument reading
R - a numeric digit of the value of the instrument reading, possibly with an embedded decimal point
E - a numeric digit of the exponent of the instrument reading
O<char> - the character <char> used to identify an overflow in the instrument reading
K<char> - a special single character <char>

If several possibilities exist for a single character, then all possibilities are placed within the parentheses. For instance, if a single character is used to indicate +, -, or overflow, it might be coded as (+1-209) defining the plus indicator as 1, the minus indicator as 2, and the overflow indicator as 9.

Consider a reading as follows: three digits of channel, a single indicating the sign of the reading or overflow, five characters indicating the value of the reading, a single character exponent and two spaces. It could be coded as:

```
READING=(C)(C)(C)(+1-209)(V)(V)(V)(V)(V)(E)(K )(K )
```

or equally

```
READING=3*(C)(+1-209)5*(V)(E)2*(K )
```

The forms EOR=EOR and EOF=EOF are used for magnetic tape media and indicate, respectively, that the data records are separated by physical record gaps on the tape and that there is a physical end-of-file mark on the tape.

Data Inputs C1 through C5 are only entered if parameter INTYPE (Data Input A1) is zero.

Input	Variables	Format	Comments
C1	IN	A80	IN - the input media definition
Input	Variables	Format	Comments
C2	IN	A80	IN - the reading definition
Input	Variables	Format	Comments
C3	IN	A80	IN - the time definition
Input	Variables	Format	Comments
C4	IN	A80	IN - the end-of-record (EOR) definition
Input	Variables	Format	Comments
C5	IN	A80	IN - the end-of-file (EOF) definition

5. Part D: Skipping Data Records on Input

Part D specifies the records to be skipped during the processing of data recorded by a data acquisition system. The records identified to be skipped are ignored on input; no translation of the skipped records is done.

There are two methods of describing which records are to be skipped:

1. Up to 16 different records can be enumerated by entering the scan number of the record to be skipped.

2. A "skip/keep" pattern, defining the records to be skipped and kept can be input.

For method 2, the input form is defined as follows:

$$SKIP=(C_1N_1)R_1\ (C_2N_2)R_2\ \ldots\ (C_{m-1}N_{m-1})R_{m-1}\ (C_mN_m)R_m$$

where

C_i = S or K or F
where, S stands for Skip
K stands for Keep
F stands for Final record

N_i = any number >= 1
where the number is an integer indicating the number of times the preceding C is to be repeated

R_i = any number >= 1
where the number is an integer indicating the last record number on which the CN pair is impacted

Like the data system format specifications, if several combinations exist for a single C_iN_i pair, than all possibilities are placed within the parenthesis. For example, if the user wishes to skip two records and one record from record 1 to record 200, it would be coded as (S2K1)200.

Consider the coding for the following requirements — The user wishes to keep records 1 to 5; skip 2 records and keep 1 record for records 6 to 150; and keep every record for records 151 to 599; record 600 is to be the last record processed:

```
SKIP=(K1)5 (S2K1)150 (K1)599 (F1)600
```

Note that care should be taken to ensure that no overlaps or conflicts exist in the pattern. If conflicts exist, the first encountered sepcification that applies to a given input record will be used, leading to potentially unpredictable results.

Part D should only be entered if parameter INSKIP (Data Input A1) is greater than zero.

Input	Variables	Format	Comments
D1a	ISKIP(1),ISKIP(2), ...,ISKIP(i) 1 <= i <= 16	16I5	This is method 1. ISKIP - the number of the record to be skipped
Input	Variables	Format	Comments
D1b	IN	A80	This is method 2. IN - the skip/keep pattern as described above

6. Part E: Input Data in Data-Acquisition-System-Dependent Formats

Part E data images are the data recorded by the data acquisition system prepared in the format recorded by a data acquisition system. Different formats, such as those described in Table 1 or as defined using Part C data images, are possible. If the data images were prepared by an earlier run of RAPID (by setting INPNCH greater than zero), the set of data images produced should be in the proper format for insertion at this point.

7. Part F: Input Data in Data-Acquisition-System-Independent Format

Part F data images are the data recorded by the data acquisition system or by and earlier run of RAPID in a format that is generated when INSAVE and/or NPNCH are greater·than zero. If the data being input were created in one of those two ways, it already should be in the correct format for insertion at this point.

If the data are being generated in some other way, the format of the inputs is as described below. One set of F1 and F2 inputs should be prepared for each instrument.

Part F data inputs are read only if parameter INTYPE (Data Input A1) is equal to 2 or 4.

Input	Variables	Format	Comments
F1	NPTS,KH,NAME1,*, NAME2	2I6, A6,A1, A60	NPTS - the number of data points for this instrument KH - the instrument number NAME1 - a six character abbreviated ID * = '*' NAME2 - a 60 character description of the instrument Note that the string '999' in columns 78-80 terminates the reading of Part F data inputs.

Input	Variables	Format	Comments
F2	REED(1),REED(2),..., REED(i) 1 <= i <= NPTS	7E11.5	Note that as many F2 inputs as necessary should be entered until all NPTS data points have been entered. REED - a data point

8. Part G: Corrections to the Data Matrix

Part G data inputs are read only if parameter NCORR (Data Input A2) is non-zero. As many additional sets of G1 and G2 inputs as are required may be included at this point to make the necessary corrections.

Input	Variables	Format	Comments
G1	IRL,IRH,ICL,ICH	4I5	The variables define a low row index (IRL), a high row index (IRH), a low column index (ICL), and a high column index (ICH) to define the portion of the data matrix to be corrected. See NPDI [9]. Note that setting IRL less than zero terminates the reading of Part G data inputs.
Input	Variables	Format	Comments
G2	REED(i,j),i=IRL,IRH, or j=ICL,ICH	8F10.0	These are the corrections to the matrix. The number of inputs required depends on the number of corrections: $G_{Int}\left[\frac{(IRH-IRL)+(ICH-ICL)+1}{8}\right]+1$ where G_{Int} represents the greatest integer function.

9. Part H: Non-Trivial Transformations of the Data Matrix

In Part B, above, it is possible to identify conversion constants for each instrument that allow the user to multiply, add to, and raise to a power, the value of each instrument by those constants.

However, in many cases the use of those constants is not sufficient to transform the raw data into values of use to the test analyst. Therefore, a large set of subroutines is included at this point to allow the conversion and manipulation of not only raw data, but also the combinations of converted data needed to produce the complex variety of values required for good fire test analysis.

The description of the input for Part H is rather extensive, so, in order to preserve the continuity of this document, it is included after Table 1.

10. Part I: Plotting

PART I

Although not always precise in the conveyance of information, printer plots can be a useful tool to the test analyst.

Three forms of plots can be used here:

1. PLOT Nx Ny1 Ny2 ... Nym

   where Ny1, Ny2, ..., Nym are any number of instrument numbers representing the y-axis values being plotted versus instrument number Nx, the x-axis values.

2. PLOT Nx1,Ny1 Nx2,Ny2 ... Nxm,Nym

   where Ny1, Ny2, ..., Nym are any number of instrument numbers representing the y-axis values being plotted versus instrument numbers Nx1, Nx2, ..., Nxm (respectively), the x-axis values.

3. PROFILE

   where, typically, values are plotted versus position rather than versus time.

Part I data inputs are read only if parameter NPLOT (Data Input A2) is non-zero.

Input	Variables	Format	Comments
I1	IN	A80	IN - one of the three forms of plots described above. If form 1 or 2 is used, and there is not enough room on one input to identify all the instrument numbers required, this input may be continued by placing a semicolon (;) on the input. See NPDI [3].
Input	Variables	Format	Comments
I2	GTITL	A80	GTITL - the 80 character graph title printed above the graph. If Form 3 of input I1 was used, GTITL is concatenated with the string ' PROFILE OF THE FOLLOWING CHANNELS:'
Input	Variables	Format	Comments
I3	JCHAN(1),JCHAN(2), ...,JCHAN(i) X 1 <= i <= 20	EVALU8 (NPDI [2])	Read this input only if Form 3 of input I1 is used. JCHAN - the instrument number of the values to be plotted in the profile (see NPDI [3]). These values are the x-axis values. X = ' X' - the end-of-set mark
Input	Variables	Format	Comments
I4	POS(1),POS(2),..., POS(j) X j=i	EVALU8 (NPDI [2])	Read this input only if Form 3 of input I1 is used. POS - the position of instruments identified with input I2; these values are the y-axis values. X = ' X' - the end-of-set mark

Input	Variables	Format	Comments
I5	JTIME,ISCAN(1), ISCAN(2),..., ISCAN(k) X 1 <= k	EVALU8 (NPDI [2])	Enter this input only if Form 3 of input I1 is used. JTIME - the time channel instrument number (see NPDI [3]). ISCAN - if ISCAN is an integer, it is the scan number of the values of the JCHAN to be used. - if ISCAN is a real (has a decimal point) it is the time of the values of the JCHAN to be used. If the time cannot be exactly matched, the time nearest without going over is used. X = ' X' - the end-of-set mark

Input	Variables	Format	Comments
I6	XL,XH,YL,YH	open (NPDI [1])	XL - lower limit of the X axis XH - upper limit of the X axis YL - lower limit of the Y axis YH - upper limit of the Y axis

Input	Variables	Format	Comments
I7	XBUFF,YBUFF	2A40	XBUFF - the 40 character x-axis title. XBUFF will be centered by the program YBUFF - the 40 character y-axis title. YBUFF will be centered by the program.

11. Notes on the Preparation of Data Inputs (NPDI) Read by RAPID

NOTES

NPDI [1] Open (List Directed) Formats

When entering values using an open (list directed) format, the value of the variable being entered must match the variable type (e.g., when entering an integer, a value with a decimal point must not be found). Therefore, variable names used in this program follow the standard convention for typing:

unless otherwise noted -

variable names beginning with the letters A through H or O through Z are real;

variable names beginning with the letters I through N are integer.

NPDI [2] Special Format Read by Subroutine EVALU8

Subroutine EVALU8 is a general purpose data input reading routine. It is called by many of the data reduction subroutines. It reads and counts the number of input values on the input, stores them and their types (integer or real) in data arrays, and returns the data and control to the calling subroutine.

An input value is defined as the string of digits and/or characters found between spaces or commas on a data input. The end of the set of values is signaled by the characters ' X' (space, X) after the last value. When no limit is imposed by the calling subroutine, up to 100 values may be read in one set. If all the values cannot fit on one input, they may continue on to the next input. Inputs will continue to be read until ' X' or an illegal character is encountered. If no digits or characters are encountered before the first comma or between commas, a real value of 0.0 is assumed.

The legal digits and characters are as follows:

```
0
1
2
3
4
5
6
7
8
9
+ (plus)
- (minus)
. (decimal point)
E (exponent)
$ (dollar sign)
, (comma)
  (space)
X
```

This subroutine will accept either integer or real values with the stipulation that the values must match the type of the variable being entered. (See NPDI [1] above). A real value must include a decimal point or "E".

The dollar sign ($) has a special meaning to this subroutine. It signals that a channel created during execution of the program is to be used. The number following the dollar sign represents the order in which the channel was created. The dollar sign and the digits are automatically replaced by the channel number in which the values are stored. See NPDI [3], below.

Note that the format described here is almost identical to "open" (list directed) format. The difference is the limit on the number of values that can be read and the special characters: the dollar sign ($) and letter X.

NPDI [3] Channels Created by the Program

This program creates new channels in which to store some of the calculated data. To identify a created channel for use by a data reduction subroutine or by the plot routine (data input I1), only the order in which the channels were created need be known. For example, to plot the data stored in the fifth channel created, enter the number '$5' where the channel number is normally entered. The program automatically replaces the dollar sign ($) and the 5 with the proper channel number. This method of identifying a channel may be used in any of the subroutines when the input data are read using subroutine EVALU8. (See NPDI [2] above). It may also be used when entering channel numbers for plots or as noted in other specific command instructions.

The dollar sign method of identifying created channels can not be used if the channel was created in a previous execution of the program. In those cases, the

channel must be handled in the normal manner, appearing in the instrument list (data input B3) and using the complete, right-justified, six-digit number.

The created channel numbers can be assigned for use in two ways: automatically by the program and by the user by means of the SPECIFY command. If the program chooses the channel number, the number is chosen such that the smallest available channel number from an unused series of channels is used. (Note: a channel series is a value from 0 to 9 and is identified by the first digit in the channel number (see NPDI [5] below). The program checks the original instrument list and determines the series which have channels used. The remaining series are put in the created channel pool for use as needed. The total number of channels that can be automatically drawn from the pool is then the number of empty series times 100. Also, for that reason, it is wise to choose a channel number for time in a series that is already being used.

NPDI [4] Saving Unreduced (Raw) Data in a Formatted Data Matrix

The option for saving raw, unreduced data in a formatted data matrix is input on Data Input A1 (Variable INSAVE). By setting INSAVE to the appropriate value the first time the raw data set is used, a formatted raw data set can be saved. Since this new data set is in a data-collection-system-independent format, the program can (in subsequent executions) read the input data without having to interpret for format correctness (i.e., read numbers instead of reading character by character), which is significantly faster.

NPDI [5] Instrument Numbers - Management of the Test Number Prefix

An instrument number is a six digit number whose first three digits represent a test number and whose last three digits represent a channel number. There are two variables, INTEST (Data Input A1) and NTEST (Data Input A2), that control the test number prefix part of the instrument numbers. INTEST controls the prefix during input, NTEST controls the prefix during output (when NPNCH (Data Input A2) is greater than zero).

INTEST can direct the program to either pass the test number through or to strip off the test number, leaving only the channel number (effectively it changes the test number prefix to 000, which is insignificant). If the test number is passed through and it is NOT insignificant, it must be used when identifying instruments for data transformations and plotting.

NTEST can direct the program to pass the test number "as is" to the saved reduced data file or to replace the test number with a value between 1 and 999 inclusive. NTEST has no effect if NPNCH is zero, since no reduced data are saved.

NPDI [6] Output of the Transformed Data Matrix

The option for printing (or not printing) the transformed data matrix is input on Data Input A2. In the SPEED2 version, the matrix is either not printed (NPRT.EQ.0) or printed (NPRT.NE.0). The RAPID version is slightly different in

that it prepares a table of minimums, maximums and averages for each channel and, consequently, the options for NPRT have also changed:

NPRT = 0, neither data matrix nor summary table is printed

< 0, only the summary table is printed

> 0, both the matrix and the summary table are printed.

This change is compatible with earlier versions of the program.

NPDI [7] Constant Value Conversion Inputs

In subroutine CONV, after all other conversions and calculations are done, the data undergo one final reduction before finally leaving the subroutine. In the SPEED2 version, this reduction is linear and of the form

```
REED = (REED * C) + ADD
```

where C and ADD are constants entered with data input B5. The RAPID version is different in that it includes an exponential value:

```
REED = ((REED * C) + ADD) ** POWER
```

where C, ADD, and POWER are the constants entered.

Data input B5 is modified as follows to accommodate the change:

Variables: C(i),ADD(i),POWER(i)

Format: 1X,3F15.6

The following default conditions exist to help avoid errors:

if ABS(POWER) < 1. and (REED * C) and ADD < 0, then the calculated value defaults to zero.

if POWER = 0., POWER defaults to 1.

The automatically assigned constant values for channels created by the program are:

C = 1.0 ADD = 0.0 POWER = 1.0

This change is compatible with earlier versions of the program.

NPDI [8] Variables in Brackets ([]) and Braces ({})

In the documentation above, some of the variables in the variable lists under each command appear within brackets ([]) or braces ({}). The variables within brackets are optional; the variables with braces are conditional. The options and/or conditions are specified to the right under the Comments. If the variable

is not used as an argument, the comma used to separate it from the other variables (if used) should also be omitted.

NPDI [9] Making Corrections to the Data Matrix

RAPID also provides the capability of modifying or correcting entries in the input matrix. Any number of corrections may be made; however, any single correction may apply only to one single entry, consecutive entries in a single column, or consecutive entries in a single row. Corrections are expected if and only if the parameter NCORR (Data Input A2) is set non-zero by the user.

Assuming NCORR is non-zero, RAPID will read a input containing the variables IRL (a low row index), IRH (a high row index), lCL (a low column index), and ICH (a high column index). The following restrictions apply:

a. Either IRL=IRH or ICL=ICH or both. Note, if IRL=IRH, all corrections apply to a single row. If ICL=ICH, all corrections apply to a single column. If IRL=IRH and ICL=ICH, a single entry will be corrected.

b. IRL is greater than zero but less than or equal to IRH or IRL is less than zero. IRL less than zero signifies the end of the corrections.

c. ICL is greater than zero but less than or equal to ICH or both ICL and ICH are less than zero. Note that ICL and ICH must be both positive or both negative. If they are negative, they are interpreted to be instrument

numbers rather than column numbers. In this case, the column i in which instrument number ICL is stored is found. Similarly, the column j in which instrument number ICH is stored is found. Then the values of ICL and ICH are replaced by i and j respectively. The restriction becomes i is greater than zero but less than or equal to j.

Failure to satisfy any of the above restrictions will result in an error message being printed and may result in all following data inputs being out of order. Thus, particular care must be taken in the preparation of this input.

There are, in effect, only three valid combinations. They are:

a. IRL is equal to IRH and ICL is equal to ICH meaning correct entry REED(IRL,ICL).

b. IRL is less than IRH and ICL is equal to ICH meaning correct entries REED(IRL,ICL), REED(IRL+1,ICL), ..., REED(IRH-1,ICL) and REED(IRH,ICL).

c. IRL is equal to IRH and ICL is less than ICH meaning correct entries REED(IRL,ICL), REED(IRL,ICL+1), ..., REED(IRL,ICH-1) and REED(IRL,ICH).

In any of the above cases, the number of entries to be corrected is

$$(IRH-IRL) + (ICH-ICL) + 1$$

These entry corrections are read from a series of data images prepared in the format 8F10.0.

Table 1. Pre-Defined Data Formats for Input to RAPID

1 - reduced data format input images
2 - pre-processed raw data input images in reduced data format
3 - VIDAR 5400 series input image format
4 - VIDAR 5400 series magnetic tape format
5 - Hewlett-Packard 9836 input image format
9 - VIDAR Autodata 9 series input image format
10 - VIDAR Autodata 9 series magnetic tape format

INTYPE	FORMAT					
			End Of Record		End Of File	
	Reading	Time	Tape	Input Image	Tape	Input Image
1	s.vvvvvEsee	s.vvvvvEsee		none		77*b999
2	s.vvvvvEsee	s.vvvvvEsee		none		77*b999
3	cccsvvvvvebb	sss6ssssssbb		bX		FILEND
4	cccsvvvvvebb	sss6ssssssbb	EOR		EOF	
5	CccccbsvvvvvvvvEeeebbX	aaaabddaaaaaaaaabhh:mm:ss		EOR		EOF
9	cccbsvvvvvvaaaeX	dd:hh:mm:ssaaaaX		bX		FILEND
10	cccbsvvvvvvaaaaX	dd:hh:mm:ssaaaaX	EOR		EOF	

a - any character
o - an overflow indicator
c - a channel number digit
s - sign of a reading
b - blank

v - magnitude of reading
e - exponent of a reading
n - a numeric (0 - 9)
r - value of a reading
d,h,m,s - days, hours, minutes, seconds of a time reading

C - the character "C"
E - the character "E"
X - the character "X"
: - the character ":"
EOR - magnetic tape end of record
EOF - magnetic tape end of file

If a number is followed by a star (*), the character immediately following the star is repeated that number of times.

12. Transformation Control Commands for Part H

COMMANDS

Data Reduction and Transformation Subroutines

There are 33 commands that the main conversion subroutine uses to call the subroutines needed to perform the data transformations routinely required for fire test data. For discussion and documentation purposes only, these commands and subroutines can be divided into three classes: utility, basic, and complex.

The utility class performs operations on reduced data such as integrating and averaging.

The basic class calculation is one in which, with the exception of temperature, only the values from one instrument are required. Typically, the basic class calculation does not create any new channels.

The complex class calculation requires at least two sets of instrument values or other information, such as instrument position. Typically, the complex class calculation creates one or more new channels in order to store the calculated results.

The subroutines that actually perform the data reduction are invoked by entering a command (beginning in column 1) with data input H1. When a subroutine is called, it will look for the additional input information needed to perform the data transformation. When the data transformation is complete, control returns to the main conversion subroutine, which looks for the next command to be executed.

A brief description of each subroutine is shown in the following sections.

12.1 Available Transformation Control Commands

12.1.1 Utility Commands

Class	Subpart	Command	Purpose
U (Utility)	a	AMBIENTS	override default values of ambient temperature, pressure and relative humidity
	b	AVERAGE	find the average of "n" channels; upper and/or lower limits may be set for each channel and the average may be weighted
	c	COMBINE	concatenate the values from more than one channel over specific intervals of the complete test in order to create a new, continuous, channel.
	d	COMPUTE	find the result of any FORTRAN-like algebraic expression; operations are add, subtract, multiply, divide, raise to a power, find minimum or maximum; operands may be constants or channel numbers
	e	DELAY	adjust the values of specific channels to account for a delay in response, etc.
	f	DELTA	find the difference between consecutive readings of the same channel

g	E119	create a channel with the standard E119 temperature (°C or F) for each time scan using an identified time channel
h	INTEGRATE	integrate a channel with respect to time
i	RENAME	give meaningful names (other than the default names) to created channels
j	SEPARATE	for channels that store information from more than one instrument, separate and store the individual results in individual channels
k	SMOOTH	reduce the "noise" in a channel using a sliding least-squares straight line fit for small sections of the curve
l	SPECIFY	specify the channel number that a created channel will receive
m	STATS	calculate various statistics regarding any particular channel: minimum, maximum, average, time to exceed a particular value, etc.
n	TIME	convert h/m/s to elapsed s and/or add a time shift to the existing, or a new, time channel

12.1.2 Basic Commands

Class	Subpart	Command	Purpose
B (Basic)	a	GAS%	calculate concentrations of different gases
	b	PRESSURE	calculate static pressure
	c	SMOKE	calculate smoke optical density
	d	THERMOCOUPLE or TC	convert voltage output to temperature for various different types of thermocouples
	e	VELOCITY	calculate gas velocity
	f	WT-LOSS	calculate total weight loss of monitored items

12.1.3 Complex Commands

Class	Subpart	Command	Purpose
C (Complex)	a	BALANCE	calculate rate of heat release from total energy balance
	b	FLOW-RATE	find neutral plane height and calculate volume flow rate, mass flow rate, and convective energy transport rate in and out of a chamber using gas velocity
	c	GAS-FLOW	calculate the mass flow rate through an opening of any gas whose concentration, velocity, and temperature are known
	d	HEAT-RATE	calculate the rate of heat release from gas concentration (oxygen depletion), gas velocity, and gas temperature
	e	HEAT-RATE-2	calculate the rate of heat release from oxygen depletion, gas velocity, and gas temperature; specifically designed for use when only one of each type of instrument is used (no profiles)
	f	HOT/COLD	find the position of the hot/cold interface as determined by the temperatures from an identified profile
	g	MASS-FLOW	calculate neutral plane height and mass flow rate of gas through an opening using gas temperature profiles
	h	MASS-FLOW-2	calculate the mass flow rate of gas through an opening using temperature profiles and a neutral plane height determined by another source

i	MASS-FLOW-3	calculate the mass flow rate of gas through an opening using a single gas velocity measurement and the area of the vent perpendicular to the gas flow
j	STATIC	find the neutral plane height, thermal discontinuity height, pressure at the thermal discontinuity height, opening gas velocities, and interior temperatures from static pressure inside chamber.
k	SURFACE	calculate average and total heat loss rate and total incident heat flux to a surface using surface temperature
l	VENT-LOSS	calculate radiative heat loss through an opening using exhaust gas temperature
m	WT-RATE	calculate percent weight loss, rate of weight loss, and rate of heat release from total weight loss
n	ZERO-TC	calculate zero diameter thermocouple temperatures from least squares fit of temperatures from various sized thermocouples

12.2 Data Input for Transformation Control Commands

The commands may be given in any order and as many times as necessary. The end of data transformation is signaled by entering the command "END".

Note that many of the subroutines called "create" new channels in which to store the calculated or transformed results. These channels must be included when counting the number of channels used. Make sure the parameter NCOL in the main program, RAPID, is large enough. Up to 1000 channels may be created by the program.

All units are metric for both input and output unless otherwise noted.

Input	Variables	Format	Comments
H1	CMD,COMENT	A80	At least the "END" command must be entered! All commands MUST begin in column 1 and MUST NOT contain any spaces. However, there are some abbreviations that may be used. The end of the command is signified by at least one space; the rest of the input may contain any comment you wish to make. An unrecognizable command will cause program termination. The inputs required by the subroutine called should directly follow each command. When the transformation performed by the subroutine is complete, the next command may be entered. Note that any part of the command in brackets is optional and the commands may be in upper or lower case. CMD = A[MBIENTS] - subroutine AMBSET class U subpart a = AV[ERAGE] - subroutine AVRAGE class U subpart b = B[ALANCE] - subroutine BALNCE class C subpart a = COMB[INE] - subroutine COMBIN class U subpart c = C[OMPUTE] - subroutine COMPUT class U subpart d = DELA[Y] - subroutine DELAY class U subpart e = D[ELTA] - subroutine DELTA class U subpart f = E[119] - subroutine E119 class U subpart g = F[LOW-RATE] - subroutine FLORAT class C subpart b

= G[AS%] - subroutine GASCON
class B
subpart a

= GAS-[FLOW] - subroutine GASFLO
class C
subpart c

= H[EAT-RATE] - subroutine RHRDOX
class C
subpart d

= H[EAT-RATE-]2 -
subroutine RHRDO2
class C
subpart e

= HO[T/COLD] - subroutine HTNCLD
class C
subpart f

= I[NTEGRATE] - subroutine INTGRT
class U
subpart h

= M[ASS-FLOW] - subroutine MASFLO
class C
subpart g

= M[ASS-FLOW-]2 -
subroutine MASFL2
class C
subpart h

= M[ASS-FLOW-]3 -
subroutine MASFL3
class C
subpart i

= P[RESSURE] - subroutine PRESS
class B
subpart b

= R[ENAME] - subroutine NUNAME
class U
subpart i

= S[EPARATE] - subroutine SEPRAT
class U
subpart j

= SM[OKE] - subroutine SMOKE
class B
subpart c

= SMOO[TH] - subroutine SMOOTH
class U
subpart k

= SP[ECIFY] - subroutine SPECFY
class U
subpart l

= ST[ATIC] - subroutine STATIC
class C
subpart j

			= STATS - subroutine STATS class U subpart m = SU[RFACE] - subroutine SURFAC class C subpart k = TH[ERMOCOUPLE] or TC - subroutine TC class B subpart d = T[IME] - subroutine TYME class U subpart n = V[ELOCITY] - subroutine GASVEL class B subpart e = VEN[T-LOSS] - subroutine VENT class C subpart l = W[T-LOSS] - subroutine WTLOSS class B subpart f = WT-R[ATE] - subroutine WTRATE class C subpart m = Z[ERO-TC] - subroutine ZDIAM class C subpart n = END - end of Part H input COMENT - beginning with the first position after the space, any comment you wish to make.

At this point enter the input specified under each command as it is given.

13. Data Input for Utility Commands

13.1 Part H, Class U, Subpart a: Input Specified by Utility Command AMBIENTS

AMBIENTS

The subroutine can assign values other than default values to the ambient temperature (°C), pressure (kPa), and relative humidity (%). The ambient air density (kg/cu m) is calculated using the ambient temperature and pressure and is not available to be set.

The default ambient values are:

Temperature	= 20 °C
Pressure	= 101.3 kPa
Relative Humidity	= 50. %
Air Density	= 1.205 kg/cu m

It is possible to give the command AMBIENTS more than once. However, any ambient that is set using this subroutine, will remain at the value given until reset also using this subroutine. The values set here are in effect and are available throughout the program. Any other subroutine that is called that requires an ambient value will use the most current value of the ambient. It is not necessary to issue the command AMBIENTS if the default values are to be used.

Input	Variables	Format	Comments
HUa1	CTRL	A80	Only one of these inputs is read each time the command AMBIENTS is given. The program searches for each of the three "key-words" that identify which ambient value is to be set: "AMBT=" - set ambient temperature, °C "AMBP=" - set ambient pressure, kPa "AMBRH=" - set ambient relative humidity, percent After each key-word, the next five characters are assumed to be the value of the ambient being set, in F format (e.g. "AMBT= 238.54" would assign the value 238. °C to the ambient temperature; the 5 and 4 are ignored since they are the sixth and seventh characters. Any or all of the ambient values may be set with this control input. If more than one value is set, be sure that at least 5 characters (including blanks) separate each key-word. The key-words may appear on the control input in any order.

Enter Another Command (Data Input H1)

13.2 Part H, Class U, Subpart b: Input Specified by Utility Command AVERAGE

The subroutine finds the average of the values from up to 25 channels. The average may be a weighted average and lower and/or upper limits for the values may be specified.

The general format for entering the information for the average is as follows:

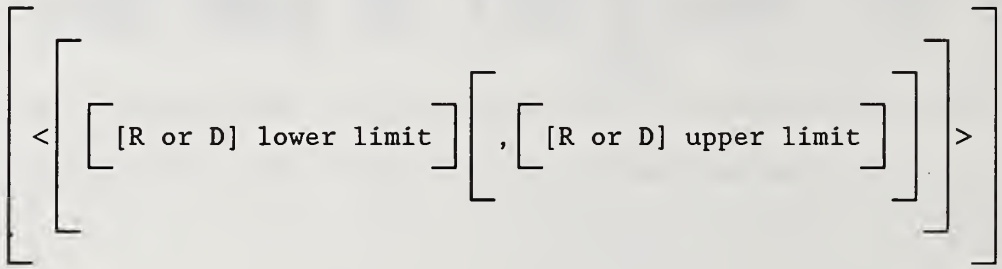
[<lim>] ch(1) [wf(1)] [<lim>] ch(2) [wf(2)] ... [<lim>] ch(i) [wf(i)] X

for 1 <= i <= 25.

In the format above, brackets (i.e., []) surround values that are optional inputs (the brackets themselves should not appear on the input input). Note that the limits (lim) appear within "limit delimiters" - <> - and that, once set, apply to the values of all channels that follow until they are reset. You may specify a lower limit only, an upper limit only, both a lower and an upper limit, or no limits. Initially no values are set and, thus, no limits will be used unless specified. Conversely, the weighting factor (wf) only applies to the channel that it follows. If no weighting factor is specified, the weighting factor defaults to 1.0. The commas are optional. The "X" signals the end of the input and is strictly required. Often, one input will not allow sufficient space to enter all the input desired. Therefore, the input may appear on any number of

inputs as long as not more than 500 characters are used (including spaces and the "X").

The specific format for entering limits is as follows:



As in the general format above, values or characters within a set of brackets are optional. To identify that limits are being entered, a set of less-than (<) and greater-than (>) symbols (limit delimiters) must surround the limits. The limits themselves may be real or integer values; however, an integer value is assumed to be a channel number. If the limit is a real value, the value of the limit is constant. If the limit is a channel number, the value of the limit is the value stored in the channel at the time being averaged. If a channel number that does not exist is entered as a limit, the run terminates.

The "R" and "D" stand for REPLACE and DELETE, respectively. If a value is outside a limit that has an "R" attached to it, the value being averaged is replaced by the limit value. If outside a limit that has a "D" attached, the value is not used to find the average and the population of the average is decreased by the weighting factor for that channel. If neither "R" nor "D" is entered, "R" is assumed.

A lower limit only, an upper limit only, both lower and upper limits, and no limits may be specified. The different combinations of limits is obtained as follows (—— indicates a channel or constant value):

```
<——> or <——,> - set lower limit only, no upper limit
        <,——> - set upper limit only, no lower limit
      <——,——> - set both limits
      <> or <,> - set no limits
```

Note that an empty field is not the same as having a limit set to zero. Also note that a comma may appear if a lower limit is set but must appear if an upper limit is to be set (an error will occur if one is not found).

The specific format for entering a weighting factor is as follows:

```
[*——]
```

where —— stands for the weighting factor value.

The brackets again indicate that the weighting factor is an optional entry. To identify that a weighting factor is being entered, a "*" must be prefixed to the weighting factor value. The value itself may be a real or an integer, but will be treated by the program as a real.

Note that anywhere in this subroutine that a channel number is allowed as an entry, a created channel number can be specified by using the method described in the Notes on the Preparation of Data Inputs Read by RAPID (see NPDI [3]).

Following is an example of a typical input record:

```
321 322*1.5 323 <320,D1000.> 324,*2,325 <> 326 <,R1000.> 327 X
```

The record above would be deciphered as follows:

Channel	Weight Factor	Lower Limit	Channel or Constant	Replace or Delete	Upper Limit	Channel or Constant	Replace or Delete
321	1.0	none	-	-	none	-	-
322	1.5	none	-	-	none	-	-
323	1.0	none	-	-	none	-	-
324	2.0	320	chan	rep	1000.	const	del
325	1.0	320	chan	rep	1000.	const	del
326	1.0	none	-	-	none	-	-
327	1.0	none	-	-	1000.	const	rep

One channel is created by the program for each average found.

Input	Variables	Format	Comments
HUb1	NAVG	open (NPDI [1])	Only one of these inputs is read each time the command AVERAGE is given. NAVG - number of average calculations to be made. Prepare NAVG sets of HUb2 inputs. NAVG channels will be created
Input	Variables	Format	Comments
HUb2	IN	A80	Any number of these inputs may be used for a single average (up to 500 characters including spaces and the "X"). IN - the input record as described in the discussion above

Enter Another Command (Data Input H1)

13.3 Part H, Class U, Subpart c: Input Specified by Utility Command COMBINE

The subroutine concatenates values from identified channels over specified ranges. The resulting data vector is stored in a channel created by the program. It is useful for combining into one channel, the values from two or more channels, such as when two instruments with different ranges are used to measure the same phenomenon.

A time (in seconds) or a scan number may be used to identify when the values from a channel are to begin being included. If a time is used, the actual scan number (j) is determined internally such that t(j-1) < time <= t(j), and where t(i) is the time at the ith scan. The values from a channel continue to be included until the next beginning scan number is reached (if there is one). If desired, times and scan numbers can both be used (a time for one channel, a scan for the next, etc.).

If the range of the first channel begins sometime after the first scan, the scans of the created channel are undefined and arbitrarily set to zero.

The scan numbers (or times) need not be entered in any particular order except that they should match the same relative order in which the channel numbers to be combined were entered. Ordering of the scans is done internally.

For example, if the combined channel were to be made up of three different data channels over four intervals, the inputs might look like this:

```
621  622  621  650  X
0.  300.  600.  250  X
```

This set of inputs instructs the subroutine to create a channel made up of the values from channel 621 from time 0. up to, but not including, the value at time 300. seconds. From 300. up to, but not including, 600., the values from channel 622. From 600. seconds up to, but not including, the value at scan 250, the values from channel 621 again. And from scan 250 to the end, the values from channel 650.

Card	Variables	Format	Comments
HUc1	NCOMB [,JTIME]	open (NPDI [1])	Only one of these inputs is read each time the command COMBINE is given. NCOMB – number of combinations of channels to be made. Prepare NCOMB sets of HUc2 and HUc3 inputs. NCOMB channels will be created. JTIME – the time channel number. If times are to be used to define the beginning of an interval, this value must be entered.
Card	Variables	Format	Comments
HUc2	JCHAN(i) X 1 <= i <= 20	EVALU8 (NPDI [2])	JCHAN – channel number of values to be included in the combination (NPDI [3]).

Card	Variables	Format	Comments
HUc3	(IB(i) or BTIME(i)) X 1 <= i <= 20	EVALU8 (NPDI [2])	These values are used to identify the beginning of the interval corresponding to the data channels above. IB – a scan number. BTIME – a time in seconds. BTIME may not be used if JTIME is not specified.

Enter Another Command (Data Card H1)

13.4 Part H, Class U, Subpart d: Input Specified by Utility Command COMPUTE

The subroutine deciphers a FORTRAN-type algebraic expression and calculates the results. The operations that can be handled are ADD (+), SUBTRACT (-), MULTIPLY (*), DIVIDE (/), RAISE TO A POWER (**), AVERAGE (A), FIND THE MINIMUM (<), and FIND THE MAXIMUM (>). (Note that AVERAGE (A), MINIMUM (<), and MAXIMUM (>) have non-standard operator symbols). The operators and operands may be nested in parentheses in order to perform the operations in the desired sequence. The operators themselves have hierarchical ranks as follows:

Function	Symbol	Rank
AVERAGE	A	3
RAISE TO A POWER	**	2
MULTIPLY or DIVIDE	* or /	1
ADD or SUBTRACT	+ or -	0
MINIMUM or MAXIMUM	< or >	0

The AVERAGE function generates the appropriate ADDs, DIVIDEs, and nesting to insure the proper average is found. Note that, unlike the averaging algorithm employed when the command AVERAGE is given, no limits or weights can be used for this average.'

When several AVERAGE operators are encountered in a string (unbroken by parentheses or other operators) all the values linked together by the A's are added before the average is found.

The MINIMUM operation finds and saves the smaller value of two values and the MAXIMUM operation does the same only for the larger value.

The operands may be either real constants or channel numbers. If an operand contains a decimal point, it is assumed to be a constant. Otherwise, the operand is assumed to be a channel number. If you wish to use channels which were created by the program, you may do so by using the method described in the Notes on the Preparation of Data Inputs Read by RAPID (see NPDI [3]). If an assumed channel is not found, the run will terminate.

A typical computation might be as follows:

```
(301 A 302 A 303 * ((20.9 - (313 < 314)) / 100.)) ** 2.  X
```

In the example above, the first step is to find the smaller value from channels 313 and 314 and then subtract that value from th constant 20.9. That result is then divided by 100.. The average of the values from channels 301, 302, and 303 is then found and then multiplied by the result of the above division. Finally, that result is squared. The "X" indicates the end of the computation and must be present. Up to 500 significant (non-blank) characters may be used to enter one computation (including the "X").

In addition there are three so-called "channel operators". The three channel operators are H (for HIGH), L (for LOW), and M (for MEAN). These operators are used to find a single value within a single channel. The syntax is to use the operator (H, L, or M) followed by a channel number; e.g., H408, L16162, M$03. The operator and its channel number are reduced to a single real number before any other calculation is done. Thus the channel operator/channel number may be used anywhere a real number may be used and must follow any syntax pertaining to real numbers.

H <channel number>	returns the highest value found in the channel.
L <channel number>	returns the lowest value found in the channel.
M <channel number>	returns the average of all the values found in the channel.

One channel is created by the program for each computation performed.

Input	Variables	Format	Comments
HUd1	NCOMP	open (NPDI [1])	Only one of these inputs is read each time the command COMPUTE is given. NCOMP - the number of computations done. Prepare NCOMP sets of HUd2 inputs. NCOMP channels will be created.
Input	**Variables**	**Format**	**Comments**
HUd2	IN	A80	As many inputs as needed may be used but the total number of significant (non-blank) characters may not exceed 500. IN - the input computation as described in the discussion above.

Enter Another Command (Data Input H1)

13.5 Part H, Class U, Subpart e: Input Specified by Utility Command DELAY

This subroutine accounts for any delay in the output due to the response time of an instrument. For any response time, r, a reading, R, at time, t, is defined as: R(t) = R(t+r). If the response time is not an even multiple of the scan rate, a straight line interpolation of the data is done.

For time, $x < t+r < y$, the interpolation and redefinition is:

$$R(t) = R(t+r) = \left[\frac{(t+r) - x}{y-x} \right] * [R(y) - R(x)]$$

No new channels are created by this command. Any changes in the data matrix take place in the identified channel.

Input	Variables	Format	Comments
HUe1	NDLAY	open (NPDI [1])	NDLAY - the number of groups of channels for which delays are to be entered. Enter NDLAY HUe2 inputs.
Input	Variables	Format	Comments
HUe2	JCHAN(1),JCHAN(2), ...,JCHAN(i),JTIME, DLAY X 1 <= i <= 98	EVALU8 (NPDI [3])	JCHAN - the channel number of the values which are delayed (NPDI [3]). JTIME - the time channel number, s. DLAY - the amount of the delay, s. X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

13.6 Part H, Class U, Subpart f: Input Specified by Utility Command DELTA

The subroutine calculates the difference between sequential values of any particular channel. The results are stored in a channel created by the program. Any channel number may be used as input. If you wish to use a channel which was created by the program, you may do so by using the method described in the Notes on the Preparation of Data Inputs Read by RAPID (see NPDI [3]).

There are two methods of calculation and storage of results as follows:

```
Method 1:
   D(1) = 0.
   D(i) = r(i) - r(i-1), for 2 <= i <= N

Method 2:
   D(i) = r(i+1) - r(i), for 1 <= i <= N-1
   D(N) = 0.
```

where D is the resulting difference, r is the value stored in the channel, and N is the total number of scans.

Input	Variables	Format	Comments
HUf1	NCHAN	open (NPDI [1])	NCHAN - the number of channels for which the incremental differences between adjacent values are calculated. Prepare NCHAN HUf2 inputs. NCHAN channels are created.
Input	Variables	Format	Comments
HUf2	JCHAN,[ICALC] X	EVALU8 (NPDI [2])	JCHAN - the channel number containing the values between which the differences are calculated (NPDI [3]). ICALC = 0, method 1, above. <> 0, method 2, above. Note that the default for a missing value is Method 1. X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

13.7 Part H, Class U, Subpart g: Input Specified by Utility Command E119

E119

The subroutine calculates the standard E119 temperature for each time from an identified time channel. The temperature may be stored as either degrees Celsius or Fahrenheit in a channel created by the program. This subroutine will only calculate values for one channel at a time and thus, it must be called each time a channel is to be created.

The equations used to calculate the temperature are as follows:

for time less than zero -

$$T = 70.$$

for time less than 2 hours -

$$T = 1044. * \text{Tanh}(0.8429 * t) - 498.2 * \text{Tanh}(0.9736 * t) + 1286. * \text{Tanh}(8.9100 * t) + 70.$$

for time equal to or greater than 2 hours -

$$T = 1632. + 75. * t + 70.$$

where,

Tanh is the hyperbolic tangent function,
T = temperature in degrees Fahrenheit, and
t = time in hours

Note that the calculation is made in degrees Fahrenheit and is converted to Celsius, if necessary.

One channel is created each time the command E119 is given.

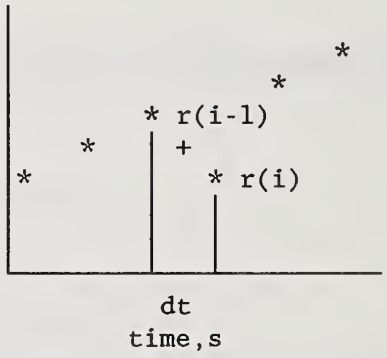
Input	Variables	Format	Comments
HUg1	JTIME,ITCODE	open (NPDI [1])	Only one of these inputs is read each time the command E119 is given. One channel is created. JTIME - time channel number ITCODE - identify output in degrees Celsius or degrees Fahrenheit: = 1, Celsius = 2, Fahrenheit

Enter Another Command (Data Input H1)

13.8 Part H, Class U, Subpart h: Input Specified by Utility Command INTEGRATE

INTEGRATE

The subroutine calculates the area under the curve with respect to time. The area is calculated using a geometric algorithm (the sum of the trapezoids defined by the segment of the curve between two points and the time axis). The calculated values are stored in a channel created by the program.



$$A(i) = SUM[a(i),i=1,n] = SUM[(r(i-1)+r(i))*dt(i)/2,i=1,n]$$

where A(i) is the total area under the curve up to point i, a(i) is the area of the "ith" trapezoid, and SUM is the summation function.

Note that the values being integrated have already been transformed using the conversion coefficients input on PLOT2 data input B5 for the original channel.

The conversion coefficients for the created channels are the default values of C = 1.0, ADD = 0.0, and POWER = 1.0.

Input	Variables	Format	Comments
HUh1	NINT	open (NPDI [1])	Only one of these inputs is read each time the command INTEGRATE is given. NINT - number of curves to be integrated. Prepare NINT HUh2 inputs. NINT channels will be created.
Input	Variables	Format	Comments
HUh2	JCHAN,JTIME X	EVALU8 (NPDI [2])	JCHAN - channel number of curve to be integrated (NPDI [3]) JTIME - reference time channel number with respect to which JCHAN is integrated, s X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

13.9 Part H, Class U, Subpart i: Input Specified by Utility Command RENAME

The subroutine allows the user to provide descriptions of the channels created by the program other than the descriptions generated by the program when a channel is created. The format used is the same as that for data inputs B3 and B4 except that the "$" signifying a created channel is recognized and the instrument type need not be identified.

Input	Variables	Format	Comments
HUi1	CHAN,ID1,ID2,KHPRT	A6,2X, A6,A60, A3	The number of HUi1 inputs is variable. The end of HUi1 format inputs is signaled by entering one HUi2 input. CHAN - the channel number being identified, right justified and including the "$" (if desired) in the left-most significant position. ID1 - a six-character, abbreviated ID. ID2 - the 60-character description. KHPRT = ' ' (blank field) - print out the values of this column on output <> ' ' (non-blank) - do not print out the values of this column

Input	Variables	Format	Comments
HUi2	IEND	77X,A3	IEND = '999' - end of the set of HUi1 inputs

Enter Another Command (Data Input H1)

13.10 Part H, Class U, Subpart j: Input Specified by Utility Command SEPARATE

SEPARATE

Often times one channel will be used to collect the data from more than one instrument by manually or automatically stepping a switch, etc. In order to plot, or otherwise compare, the individual values, it is necessary to resolve the channel into its separate parts. Since the time at which the "nth" value of each part is recorded is different, the time channel must also be resolved into separate parts.

The subroutine resolves both the data and time channels into parts according to a pattern, or "separation code", provided by the user. Various, repeatable patterns may be needed to identify which scans belong to which instrument. The separation code format allows for an infinite number of variations.

In general, the separation code consists of the "skip/keep" pattern in parentheses followed by the scan number of the last scan to which the pattern applies:

([skip/keep pattern]) [scan number] ([skip/keep pattern]) [scan number] ...

The skip/keep pattern is repeated until the scan number is reached. The pattern itself consists of a series of letters and numbers signifying skip or keep and

how many scans of each. The letter 'S' stands for skip; the letter 'K' stands for keep. Any number of alternating skips and keeps may appear in the pattern.

Example 1

The channel has the values from three instruments stored in it and each instrument is recorded every third scan. There were 295 scans taken. The separation codes for the three instruments would be:

Instrument 1:	(K1S2)295	(keep scans 1, 4, 7, ..., 295)
Instrument 2:	(S1K1S1)295	(keep scans 2, 5, 8, ..., 293)
Instrument 3:	(S2K1)295	(keep scans 3, 6, 9, ..., 294)

Example 2

One set of instruments' values stored in the channel was recorded such that, to recover them, every first, third, fourth and sixth scans are skipped and every second and fifth are kept, up to scan 100. From scan 101 to 295 (end of test), every other scan is kept. The separation code would be:

(S1 K1 S2 K1 S1)100 (S1 K1)295

Alternatively, the letter 'E' may be used to signify the last scan recorded:

(S1 K1 S2 K1 S1)100 (S1 K1)E

Spaces in the code are ignored except that if a space follows a number, the whole number is assumed to be to the left of the space:

```
(S1K1S   2 K1 S1)  100(S 1K 1  )  E
```

is the same as the code above.

The following syntax rules should be used when preparing the separation code:

1. A '(' should be the first significant character on the input and should be the first significant character, if any, after a scan number.
2. An 'S' or a 'K' must be the next significant character after '('
3 A "repeat" number must follow 'S' or 'K' even if it is 1
4. An 'S', 'K', or ')' must be the next significant character following a repeat number.
5. A scan number or 'E' must be the next significant character(s) following ')'.
6. Spaces are ignored except that if a space follows a number, the whole number is assumed to be to the left of the space.

Note that if an 'E' is not used and the last scan number given is not greater than or equal to the number of scans in the channel, all scans past the last scan number given are skipped. If the last scan number given is greater than the number of scans used, the "skip/keep" pattern is repeated until the last scan used is reached.

The conversion coefficients of the original channel (identified by ITYPE on data input B3 and entered with data input B5) are also used by the newly created channel.

Both the separated values and the separated time are stored in new channels created by the program.

Input	Variables	Format	Comments
HUj1	JTIME,JCHAN,NPART X	EVALU8 (NPDI [2])	Only one of these inputs is read each time the command SEPARATE is given. JCHAN - channel number of data to be separated into parts (NPDI [3]). JTIME - reference time channel number NPART - number of parts into which data is to separated. Prepare NPART HUj2 input(s) X - ' X' - end-of-set mark.
Input	Variables	Format	Comments
HUj2	PAT	A80	2 channels created for every HUj2 input read: first is for data, second is for time. PAT - 80 character separation code: 1) first character must be '(' 2) 'S' or 'K' must follow '(' 3) "repeat" number must follow 'S' or 'K' 4) 'S', 'K', or ')' must follow "repeat" number 5) scan number or 'E' must follow ')' 6) spaces are ignored except they must not be in the middle of numbers

Enter Another Command (Data Input H1)

13.11 Part H, Class U, Subpart k: Input Specified by Utility Command SMOOTH

SMOOTH

The subroutine will smooth "noisy" data by finding the least squares straight line fit for small sections, or "windows", of the curve. The window is an odd number of adjacent values from the channel being smoothed along with the corresponding values from the time channel. The smoothed value at the center of the window is calculated from the equation of the fit line and stored in a new channel created by the program. After the smoothed point is calculated and stored, the window slides up, dropping the "oldest" value and adding a new one. A new straight line is determined and the point calculated and stored. The process is repeated until the entire curve is smoothed.

Note that any odd number of points may be used, but a small number is preferable when the trend of the curve shows a rapid increase or decrease.

It is possible to re-smooth a curve simply by entering the created channel number of a previously smoothed curve as the channel to be smoothed (see NPDI [3]).

The equation of the line is of the form: $S(i) = A * x(i) + B$, where $S(i)$ is the calculated "ith" smooth point, $x(i)$ is the "ith" time value, and A and B are determined by:

$$A = \frac{n * SUM[x(i)*y(i),i=a,b] - SUM[x(i),i=a,b] * SUM[y(i),i=a,b]}{n * SUM[(x(i)**2),i=a,b] - (SUM[x(i),i=a,b])**2}$$

$$B = \frac{SUM[y(i),i=a,b] - A * SUM[x(i),i=a,b]}{n}$$

where n is the number of points in the window between point a and point b, x(i) is the "ith" time reading, y(i) is the "ith" value from the curve being smoothed, and SUM is the summation function.

Note that the values being smoothed have already been transformed using the conversion coefficients input on data input B5 for the original channel. The conversion coefficients for the created channels are the default values of C = 1.0, ADD = 0.0, and POWER = 1.0.

Input	Variables	Format	Comments
HUk1	NCHAN	open (NPDI [1])	Only one of these inputs is read each time the command SMOOTH is given. NCHAN - number of channels to be smoothed. Prepare NCHAN HUk2 inputs. NCHAN channels will be created.

Input	Variables	Format	Comments
HUk2	JCHAN,JTIME [,NPTS] X	EVALU8 (NPDI [2])	JCHAN - channel number of data to be smoothed (NPDI [3]) JTIME - time channel number NPTS - number of values in "window" (default value is 3) X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

13.12 Part H, Class U, Subpart 1: Input Specified by Utility Command SPECIFY

The subroutine allows the user to specify the channel number that the next "n" created channels will be given (see NPDI [3]). Up to 100 channel numbers can be specified at a time. A channel number can be specified more than once with no message given. If a specified channel has already been used, the values in that channel are over-written. If all the channels from a previous SPECIFY command have not been used when a new SPECIFY command is given, the left-over channels from the previous command are NOT used. It is possible for more than one created channel reference ($xxx) to point to the same channel and a single channel may, at different points in the execution, contain more than one set of reduced data. It is therefore very important that care be exercised when using this command.

NOTE - THIS CAN BE A VERY DANGEROUS COMMAND.

Input	Variables	Format	Comments
HU11	JSPEC(i) X i <= 1 <= 100	EVALU8 (NPDI [2])	JSPEC - a channel number to be used when a channel is created, in order of usage (NPDI [3]). X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

13.13 Part H, Class U, Subpart m: Input Specified by Utility Command STATS

The subroutine calculates various statistics with respect to the values from any particular channel. It finds the minimum and maximum values and the times at which those values first occur. It calculates the average value for the test. It compares the values from the channel to a constant or the values from some other channel and determines:

1. the first time at which the value of the channel is less than the comparison value and greater than the comparison value, and

2. the total time less than the comparison value, and greater than the comparison value.

In addition, the time range over which the statistics are determined can be specified.

This subroutine does not reduce any raw data and does not create any new channels.

Input	Variables	Format	Comments
HUm1	NSTATS	open (NPDI [1])	NSTATS - the number of blocks of channels for which statistics are to be determined. Prepare NSTATS HUm2 inputs.

Input	Variables	Format	Comments
HUm2	JCHANL,JCHANH,CMPVAL or JCOMP,JTIME [,TIMELO or ITIMEL [,TIMEHI or ITIMEH]] X	EVALU8 (NPDI [2])	JCHANL - the first channel number in the block of channels (NPDI [3]). JCHANH - the last channel number in the block of channels (NPDI [3]). Note that JCHANL and JCHANH should be determined by the order of the instrument list (data inputs B3). If there is only one channel in the block, JCHANH should be the same as JCHANL which should be the channel. CMPVAL - a constant comparison value. JCOMP - the channel number of the values to be used for comparison. JTIME - the time channel number. TIMELO - the time(s) at which to begin determining the statistics, default is time of first scan. ITIMEL - scan number at which to begin determining the statistics, default is 1. TIMEHI - the time(s) at which to end determination of statistics, default is time of last scan. ITIMEH - scan number at which to end determination of statistics, default is the last scan. X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

13.14 Part H, Class U, Subpart n: Input Specified by Utility Command TIME

The subroutine can change the readings stored in a specified channel from hours/minutes/seconds format to elapsed seconds, and/or add a time shift. The results may be stored back in the original channel (destroying the old values) or they may be stored in a new channel (saving the old values in the original channel).

H/M/S Conversion to S

The hours / minutes / seconds to seconds conversion is not needed unless the program expects the time reading to be in seconds format but was recorded in hours / minutes / seconds format. If the program gets the format it expects, the time is automatically converted to seconds.

Time Shift

The time shift is used when "time-zero" occurs before or after the data acquisition system is started. If the event marking the beginning of the test occurs before the start of the data acquisition, the time shift will be a positive value; if it occurs after, the time shift will be a negative value.

New Channel

The new channel is created automatically by the program at the option of the user. However, it is not always necessary to store the adjusted time in a new channel. If the old values in the original channel are not required, and the size of the data matrix is critical, it is recommended that a new channel not be used.

Note that, alternatively, if a new channel is not needed, the hours / minutes / seconds to seconds conversion and the time shift can be performed without using the TIME command by using appropriate coded part B (instrument identification and conversion coefficient) and part C (reading format) data inputs.

Input	Variables	Format	Comments
HUnl	JTIMEO,ITIME,IHMS, TSHIFT	open (NPDI [1])	Only one of these inputs is read each time the command TIME is given. JTIMEO - original time channel number ITIME > 0 - create new time channel to store adjusted time (1 channel created) IHMS > 0 - perform h/m/s to s conversion TSHIFT - time shift, s

Enter Another Command (Data Input Hl)

14. Data Input for Basic Commands

14.1 Part H, Class B, Subpart a: Input Specified by Basic Command GAS%

The subroutine calculates the volume percent concentrations of gas from the output of four different types of analyzers.

Types 1 and 2

For analyzer types 1 and 2, the concentration is calculated using a natural log fit of the calibration curve (actually the inverse of Beer's Law, which is an exponential). The calibration curve is the relationship of the concentration to the analyzer meter reading and not necessarily to the recorded analyzer output. The actual calculation is made by first changing the recorded output to an equivalent meter reading and then using that meter reading in the calibration curve equation to find the concentration:

$$M = \frac{R - R(0)}{R(s) - R(0)} * M(s)$$

where M is the calculated meter reading corresponding to output R, M(s) is the known meter reading for known output R(s), and R(0) is the output for zero percent concentration of gas. Then,

$$C = -a * \ln(1.0 - (M/b))$$

where C is the calculated concentration, M is the meter reading calculated above, and a and b are the curve fit coefficients.

Type 2 analyzers differ from type 1 analyzers only in that they may use two ranges during a test and, thus, two calibration curves. The range change may be indicated automatically by a voltage change in a dummy channel or it may be indicated by entering the scan number or time of the switch. There are advantages and disadvantages to each type of indicator. The automatic indicator allows an unlimited number of switches between the two ranges but the output voltages must be less than and greater than one volt to indicate the change. If either the scan number or the time is used to indicate the switch, only one switch can be used. In addition, if the time is used, the time channel number must have an ITYPE equal to 1 (see PLOT2 data input B3).

Coefficients for calibration curves can be catalogued in the program. A BLOCK DATA subroutine for this purpose has already been prepared. An example can be found in Appendix B.

If the calibration curve you need is not already catalogued, find the coefficients for the curve and enter them with the appropriate data input (data input HBa2.1 or HBa3.1).

Type 3

The change in output from type 3 analyzers is linearly proportional to the change in concentration of the gas. Once the slope of the line is found, any concentration may be calculated. To define the slope, two points must be known, typically the "zero" and one other point. The concentration, C, for any output R then becomes:

$$C = \frac{C(s) * (R - R(0))}{R(s) - R(0)}$$

where R(0) is the output for zero concentration and R(s) is the output for known concentration C(s).

Type 4

The concentration recorded by type 4 analyzers is proportional to 10**(-R/k), where R is the recorded output and k is a constant determined by the analyzer characteristics.

To find k, two concentrations and their corresponding outputs must be known:

$$k = \frac{R(2) - R(1)}{\log (C(1) / C(2))}$$

where R(1) is the output corresponding to C(1) and R(2) is the output corresponding to C(2). Note that neither C(1) nor C(2) may be zero.

Then the concentration, C, for any output R is

$$C = \frac{C(s)}{10**((R-R(s))/k)}$$

where R(s) is the known output for C(s) and k is as calculated above. In this program C(1) equals C(s).

For all four types of analyzers, the calculated concentrations (volume percent) replace the raw data values in the data matrix; no new channels are created.

Input	Variables	Format	Comments
HBa1	NGAS	open (NPDI [1])	Only one of these inputs is read each time the command GAS% is given. NGAS - number of gas analyzers. Prepare NGAS set(s) of HBa2 through HBa5 inputs

Input	Variables	Format	Comments
HBa2.1	JCHAN,ITYPE,IDNO, ZERO,SPAN,SM {,CA,CB} X	EVALU8 (NPDI [2])	JCHAN - analyzer channel number (NPDI [3]) ITYPE - analyzer type code. Use this input format only if ITYPE = 1 - single range calibration curve IDNO - curve number of analyzer and range to be used = 0, if analyzer is not in catalog (read input HBa2.2) ZERO - output for zero concentration of gas SPAN - output for a known concentration of gas SM - meter reading for span concentration CA,CB - calibration curve coefficients. Enter these values only if IDNO=0. X = ' X' - end-of-set mark
HBa2.2	SERNO,GAS,RANGE	A8,A8, A5	Read this input only if IDNO = 0 (see input HBa2.1). SERNO - analyzer serial number GAS - type of gas analyzed RANGE - maximum concentration of gas for analyzer (volume %)
Input	Variables	Format	Comments
HBa3.1	JCHAN,ITYPE,IDNO1, IDNO2,LHTYPE,LOHI, ZERO,SPAN1,SM1 {,CA1,CB1},SPAN2, SM2 {,CA2,CB2} X	EVALU8 (NPDI [2])	JCHAN - analyzer channel number ITYPE - analyzer type code. Use this input format only if ITYPE = 2 - double range calibration curve IDNO1 - first curve number of analyzer and range to be used = 0, if analyzer is not in catalog (read input HBa3.2) IDNO2 - second curve number of analyzer and range to be used = 0, if analyzer is not in catalog (read input HBa3.3) LHTYPE = 1 - range 1 and range 2 are identified by the output values of another channel: output < 1. - range 1, output => 1. - range 2 = 2 - switch from range 1 to range 2 at a particular scan

			= 3 - switch from range 1 to range 2 at or after a particular time LOHI - if LHTYPE=1, the channel number of the switch indicator - if LHTYPE=2, the scan number of the first scan after the switch - if LHTYPE=3, the time in seconds at or after which the switch is made (the comparison is made with the time channel identified by ITYPE = 1 from data input B3 after all reduction has been performed including by conversion coefficients C, ADD, and POWER identified on data input B5) ZERO - output for zero concentration of gas SPAN1 - output for a known concentration of gas on the first range SM1 - meter reading for SPAN1 concentration CA1,CB1 - calibration curve coefficients Enter these values only if IDNO1=0. SPAN2 - output for a known concentration of gas on the second range SM2 - meter reading for SPAN2 concentration CA2,CB2 - calibration curve coefficients Enter these values only if IDNO2=0. X = ' X' - end-of-set mark
HBa3.2	SERNO,GAS,RANGE1, RANGE2	A8,A8 A5,A5	Read this input only if IDNO1 and IDNO2 = 0. (see input HBa3.1). SERNO - analyzer serial number GAS - type of gas analyzed RANGE1 - maximum concentration of gas for 1st range of analyzer (volume %) RANGE2 - same as above but for 2nd range
HBa3.3	{RANGE1} {RANGE2}	A5	Read this input if only IDNO1=0 or only IDNO2=0. (see input HBa3.1). RANGE1 - same as for input HBa3.2. Enter this value only if IDNO1=0.

			RANGE2 - same as for input HBa3.2. Enter this value only if IDNO2=0

Input	Variables	Format	Comments
HBa4	JCHAN,ITYPE [,ZERO] [,SPAN],CON x	EVALU8 (NPDI [2])	JCHAN - analyzer channel number (NPDI [3]). ITYPE - analyzer type code. Use this input format only if ITYPE = 3 - change in gas concentration linearly proportional to change in analyzer output ZERO - output for zero concentration of gas. Note: if only three arguments are entered with this input, ZERO is assumed = 0.0. SPAN - output for a known concentration of gas. Note: if only three or four arguments are entered with this input, SPAN is set equal to the first reading of the analyzer. CON - span gas concentration (volume %) X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HBa5	JCHAN,ITYPE,C1,R1, C2,R2 X	EVALU8 (NPDI [2])	JCHAN - analyzer channel number (NPDI [3]). ITYPE - analyzer type code. Use this input format only if ITYPE = 4 - gas concentration proportional to 10**(-R/k) C1 - known concentration of gas, volume % (not equal to zero) R1 - output for known concentration C1 C2 - known concentration of gas different than C1, volume % (not equal to zero) R2 - output for known concentration C2 X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

14.2 Part H, Class B, Subpart b: Input Specified by Basic Command PRESSURE

PRESSURE

The subroutine calculates static pressure from the output of pressure transducers. A static pressure probe is two sided and senses the difference in pressure between one side and the other. A typical use for the probe is to measure the pressure difference between the inside and outside of a test chamber.

For all the static pressure calculations, the calculated values replace the raw data values in the data matrix; no new channels are created.

Input	Variables	Format	Comments
HBb1	NSTAT	open (NPDI [1])	Only one of these inputs is read each time the command PRESSURE is given. NSTAT - number of channels to be converted from raw data to static pressure. Prepare NSTAT HBb2 input(s)

Input	Variables	Format	Comments
HBb2	JCHAN,ZERO,CON X	EVALU8 (NPDI [2])	JCHAN - pressure probe channel number (NPDI [3]). ZERO - output for zero pressure difference (ambient) CON - conversion factor from output to static pressure (pascals per unit output) X = ' X' - end-of-set mark.

Enter Another Command (Data Input H1)

14.3 Part H, Class B, Subpart c: Input Specified by Basic Command SMOKE

The subroutine calculates the optical density per unit length from the recorded output of a smoke meter. There are three types of relationships between the optical density and the output.

Type 1 - optical density proportional to the log of the inverse of the fraction of full transmission, output decreasing for transmission decreasing.

Type 2 - same as type 1 but output increasing for transmission decreasing.

Type 3 - optical density linearly proportional to the zero-adjusted output voltage

Type 4 - extinction coefficient linearly proportional to the zero-adjusted output voltage

For types 1 and 2,

$$O.D. = \log (1/P)$$

where O.D. is the optical density and P is the fraction of full transmission

$$P = \frac{R - R(0)}{R(1) - R(0)}$$

where R is any recorded output, R(1) is the output at full transmission, and R(0) is the output at zero transmission.

Note that the equation for optical density will not allow P equal to zero and, thus, R may not equal R(0). Since, in practice, the meter cannot sense less than one hundredth of one percent of full transmission, that value is assumed equal to zero and for any value less than that the optical density defaults to 5.0.

For types 3 and 4,

$$S = (R - R(1)) * C$$

where S is either the optical density (type 3) or the extinction coefficient (type 4) and C is the calibration factor for the smoke meter,

$$C = \frac{\text{change in S}}{\text{change in voltage output}}$$

For all the optical density calculations, the calculated values replace the raw data values in the data matrix; no new channels are created.

Input	Variables	Format	Comments
HBc1	NMETER	open (NPDI [1])	Only one of these inputs is read each time the command SMOKE is given. NMETER - number of smoke meters. Prepare NMETER HBc2 input(s)

Input	Variables	Format	Comments
HBc2	JCHAN,JTYPE [(,PATH) [,ICONV [,R100 [(,R0)]]]] ([,CAL]) X	EVALU8 (NPDI [2])	JCHAN - smoke meter channel number (NPDI [3]). JTYPE = 1 - optical density proportional to the log of the inverse of percent of full transmission; output decreasing for transmission decreasing = 2 - same as type 1 but output increasing for transmission decreasing = 3 - optical density linearly proportional to zero adjusted voltage = 4 - extinction coefficient linearly proportional to zero adjusted voltage PATH - effective path length of smoke meter, m. Enter this value only if JTYPE = 1,2 or 3. ICONV - If INCONV <> 0, convert optical density to extinction coefficient for types 1, 2 and 3 or convert extinction coefficient to optical density for type 4. R100 - output for 100% transmission R0 - output for 0% transmission. Enter this value only if JTYPE = 1 or 2. CAL - change in optical density or extinction coefficient per unit change in voltage output. Enter this value only if JTYPE = 3 or 4. X = ' X' - end-of-set mark used by subroutine EVALU8

Enter Another Command (Data Input H1)

14.4 Part H, Class B, Subpart d: Input Specified by Basic Command THERMOCOUPLE

The subroutine calculates the temperature in degrees C (Celsius), F (Fahrenheit), K (Kelvin), or R (Rankine) from the thermocouple output voltage using an eight-segment curve fit for seven different types of thermocouples: E, S, J, T, K, B and R.

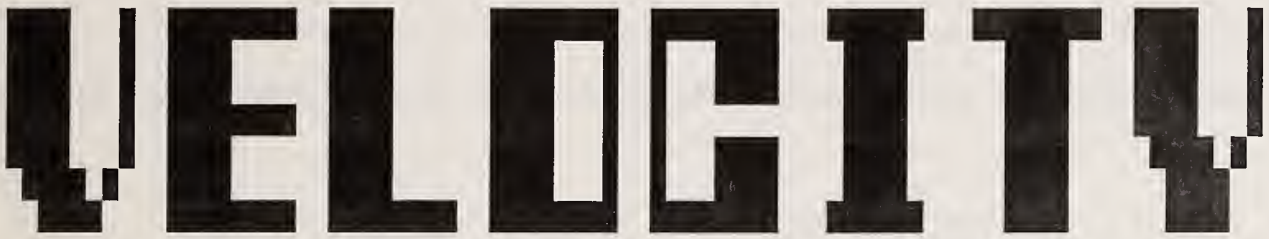
The instruments to be converted are entered in blocks, identifying only the first and last instruments in the block. A block is a contiguous set of B3 data inputs. Note that the input for this command can be simplified by grouping all the thermocouple channels together in the instrument list (Data Input B3).

Input	Variables	Format	Comments
HBd1	NTCGRP	open (NPDI [1])	NTCGRP - the number of thermocouple blocks to be converted. Prepare NTCGRP HBd2 inputs.

Input	Variables	Format	Comments
HBd2	JLOW,JHI [JT[,ISCALE]] X	EVALU8 (NPDI [2])	JLOW - the first thermocouple instrument number of the block. (NPDI [3]). JHI - the last thermocouple instrument number of the block. (NPDI [3]). JT - the thermocouple type. i.d. number: 1 - Type E 2 - Type S 3 - Type J 4 - Type T 5 - Type K 6 - Type B 7 - Type R The default type for missing or invalid input is 5 (Type K). ISCALE - the output temperature units i.d. number: 1 - °C 2 - °F 3 - °K 4 - °R The default units for missing or invalid input is 1 (°C). X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

14.5 Part H, Class B, Subpart e: Input Specified by Basic Command VELOCITY



The subroutine calculates the gas velocity from the output of a velocity probe (pressure transducer). There are two kinds of probes: mono-directional (pitot tube) and bi-directional. Essentially, the probes sense the dynamic air pressure on them and the transducers convert it to a voltage output.

Pressure Calculation

The conversion factor for changing the voltage output to pressure (the sensitivity) must be known (e.g., 10V = 1" H2O = 248.7 Pa). The pressure, P, is then

$$P = (R - R(0)) * S$$

where R(0) is the output at ambient pressure, R is the recorded output, and S is the sensitivity (Pa/output unit).

Gas Density Calculation

In addition to the pressure, the gas density, p, is also necessary. The gas density is directly proportional to the absolute gas temperature: by the gas law

$$p = \frac{p(0) * T(0)}{T}$$

where p(0) and T(0) are known, related gas density (kg/m^3) and temperature (K) and T is the input gas temperature (K). Note that p(0)*T(0) is constant and equal to 353 $kg*K/m^3$.

Input Temperature

The input temperature for the gas density calculation may be from one of three different sources:

1. A single temperature from one, or the average of several, thermocouples located near the velocity probe;
2. An arbitrary, constant temperature supplied by the user;
3. An interpolated temperature from the values of two thermocouples near the velocity probe.

Velocity Calculation

For mono-directional probes (pitot tubes), the velocity, v, is calculated by

$$v = (2. * P / p) ** 0.5$$

where P is the pressure in pascals (Pa) and p is the gas density (kg/m^3).

$$Pa = \frac{N}{m^2} = \frac{kg * m}{s^2 * m^2}$$

$$p = \frac{p(0) * T(0)\ (K * kg / m^3)}{T\ (K)} = \frac{353}{T}\ (kg / m^3)$$

Substituting the proper units back into the velocity equation yields

$$v = 0.0753 * (P * T) ** 0.5 \quad m/s$$

The equation for bi-directional probes is similar

$$v = (1.717 * P / p) ** 0.5$$
$$= 0.0698 * (P * T) ** 0.5 \quad m/s$$

Note that the bi-directional probes measure velocity in two directions. In this subroutine, which direction is positive and which is negative has no real meaning. However, in subroutine FLORAT the convention is that the positive direction is out of the test chamber and the negative direction is into the test

chamber. Mono-directional probes should be consistent with any bi-directional probes and/or with each other.

This subroutine replaces the raw data in the data matrix with the calculated gas velocities; no new channels are created.

Input	Variables	Format	Comments
HBe1	NPROBE	open (NPDI [1])	Only one of these inputs is read each time the command VELOCITY is given. NPROBE - number of velocity probes. Prepare NPROBE HBe2 input(s)
Input	Variables	Format	Comments
HBe2	JCHAN,SEN,ZERO, JPTYPE,JTMETH {,JTEMP} {,CTEMP} {,POSJ,JTEMP1, PTEMP1,JTEMP2, PTEMP2} X	EVALU8 (NPDI [2])	JCHAN - velocity probe channel number (NPDI [3]). SEN - sensitivity (or calibration) of transducer (pascals per output unit) ZERO - transducer output for no-flow condition

JPTYPE - velocity probe type code
= 1 - mono-directional probe, positive change in output for positive change in gas flow
= -1 - mono-directional probe, negative change in output for positive change in gas flow
= 2 - mono-directional probe, positive change in output for negative change in gas flow
= -2 - mono-directional probe, negative change in output for negative change in gas flow
= 3 - bi-directional probe, positive change in output for positive change in gas flow
= -3 - bi-directional probe, negative change in output for negative change in gas flow

Note: by convention, if the gas flow rate is being measured in and out of a test chamber, the out-flow is assumed to be in the positive direction. If only one direction is being investigated, assume it to be the positive direction

JTMETH - velocity probe temperature correction method code
= 1 - a single temperature from a thermocouple near the velocity probe
= 2 - an arbitrary, fixed temperature
= 3 - an interpolation of temperature between two thermocouples near the velocity probe

JTEMP - a single temperature channel number, °C (NPDI [3]). Enter this value only if JTMETH = 1.

CTEMP - an arbitrary constant temperature, °C. Enter this value only if JTMETH = 2.

			POSJ - position of velocity probe relative to an arbitrary origin, m. Enter this value only if JTMETH = 3 JTEMP1 - the upper temperature channel number (by probe position) used in interpolation, °C (NPDI [3]). Enter this value only if JTMETH = 3 PTEMP1 - position of JTEMP1 relative to same origin as probe, m. Enter this value only if JTMETH = 3 JTEMP2 - the lower temperature channel number (by probe position) used in interpolation, °C (NPDI [3]). Enter this value only if JTMETH = 3 PTEMP2 - position of JTEMP2 relative to same origin as probe, m. Enter this value only if JTMETH = 3 X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

14.6 Part H, Class B, Subpart f: Input Specified by Basic Command WT-LOSS

WT-LOSS

The subroutine calculates the total weight loss of an item that is being weighed by a load cell.

The change in weight is linearly proportional to the change in output and the total weight loss is defined as

$$T = C * (R(1) - R)$$

where T is the total weight loss (kg), R(1) is the output at the beginning of the test (i.e. the output corresponding to the initial weight), R is any output, and C is the conversion factor from volts to kg.

If the initial weight, W (kg), of the weighed item and the output, R(0), for zero weight are known, C can be calculated by the program as

$$C = \frac{W}{R(1) - R(0)}$$

otherwise C must be input.

For all the total weight loss calculations, the calculated values replace the raw data values in the data matrix; no new channels are created.

Input	Variables	Format	Comments
HBf1	NCHAN	open (NPDI [1])	Only one of these inputs is read each time the command WT-LOSS is given. NCHAN - number of weight loss channels. Prepare NCHAN HBf2 input(s)
Input	**Variables**	**Format**	**Comments**
HBf2	JCHAN{,ZERO,WEIGHT} {,CON} X	EVALU8 (NPDI [2])	JCHAN - load cell channel number (NPDI [3]). ZERO - output for zero weight. Enter this value only if it and the initial weight are known. WEIGHT - initial total weight of items on load cell, kg. Enter this value only if it and the output for zero weight are known. CON - the output to weight conversion factor. Enter this value only if ZERO or WEIGHT is unknown. X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15. DATA INPUT FOR COMPLEX COMMANDS

15.1 Part H, Class C, Subpart a: Input Specified by Complex Command BALANCE

BALANCE

The subroutine solves an energy balance equation to find the rate of heat release of the system:

$$E(i) + Q' - Q(s) - Q(o)\ E(o) = 0$$

where

- E(i) - the convective energy transfer rate into the system, kW (equals the product of the mass flow rate and enthalpy into system, calculated in subroutine FLORAT)
- E(o) - the convective energy transfer rate out of the system, kW (equals the product of the mass flow rate and enthalpy out of system, calculated in subroutine FLORAT)
- Q(s) - total heat loss rate to surfaces, kW (calculated in subroutine SURFAC)
- Q(o) - total heat loss rate through an opening, kW (calculated in subroutine RHLOPN)
- Q' - rate of heat release of system, kW

Rearranging and solving for the rate of heat release of the system we have:

$$Q' = Q(s) + Q(o) + M(o) * E(o) - M(i) * E(i)$$

The calculated results are stored in a channel created by the program. The subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HCa1	JEIN(1),JEOUT(1), JEIN(2),JEOUT(2), ...,JEIN(i), JEOUT(i) X 1 <= i <= 5	EVALU8 (NPDI [2])	Enter convective energy flow rate in and flow rate out channel numbers in pairs. JEIN - convective energy flow rate into chamber, kW (NPDI [3]) JEOUT - convective energy flow rate out of chamber, kW (NPDI [3]) X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCa2	JWALL(1),JWALL(2), ...,JWALL(i) X 1 <= i <= 10	EVALU8 (NPDI [2])	JWALL - total radiative rate of heat loss to surfaces channel number, kW (NPDI [3]) X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCa3	JOPEN(1),JOPEN(2), ...,JOPEN(i) X 1 <= i <= 5	EVALU8 (NPDI [2])	JOPEN - total radiative rate of heat loss through an opening channel number, kW (NPDI [3]) X = ' X' - end-of-set mark used by subroutine EVALU8

Enter Another Command (Data Input H1)

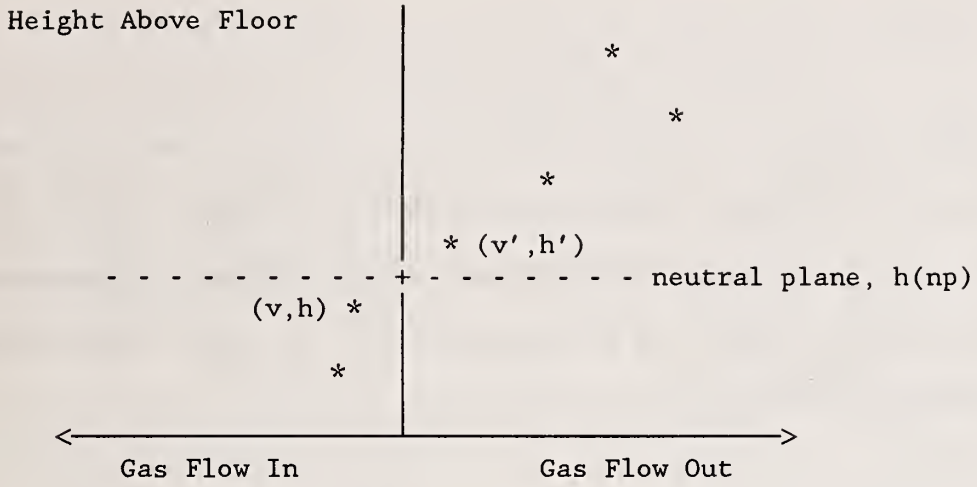
15.2 Part H, Class C, Subpart b: Input Specified by Complex Command FLOW-RATE

FLOW-RATE

The subroutine makes four separate calculations based on the gas velocity (m/s) profile of an opening in the test chamber: 1) neutral plane height (m) of the opening; 2) volume flow rate (m^3/s) in and out of the opening; 3) mass flow rate (kg/s) in and out of the opening; and 4) convective energy transfer rate (kW) in and out of the opening. The seven different calculated values are all stored in their own channels created by the program. This subroutine does not reduce any raw data.

Neutral Plane

The neutral plane height calculation requires a velocity profile of the opening being investigated. The velocities are checked from top to bottom for gas flow reversal. When reversal is found, the neutral plane height is calculated by interpolating the two velocities and the positions of the velocity probes to find the position of zero velocity (the neutral plane).



$$h(np) = h + \frac{-v * (h' - h)}{v' - v}$$

Volume, Mass, and Convective Energy Flow Rates

For all three kinds of calculated flow rates, the flow rate is proportional to the product of the velocity, v (m/s), the opening height, H (m), and the opening width, W (m):

volume flow rate, $V = v * H * W$

mass flow rate, $\dot{M} = V * p$, where p is the gas density

energy flow rate, $E = M * C(p) * dT$, where C(p) is the specific heat of the gas and dT is the difference between the absolute gas temperature, T (K), and absolute ambient temperature, T(amb) (K)

For air,

$$C(p) = 0.9126 + 2.577 * 10^{**}(-4) * T - 3.974 * 10^{**}(-8) * T^{**}2$$

Both the mass and energy flow rate calculations require the gas temperature to make the calculations (to find p and dT respectively). The input temperature may be from three different sources:

1. an arbitrary constant temperature supplied by the user;
2. a single temperature from one, or the average of several, thermocouple(s) located near the velocity probe;
3. an interpolated temperature from the values of two thermocouples near the velocity probe.

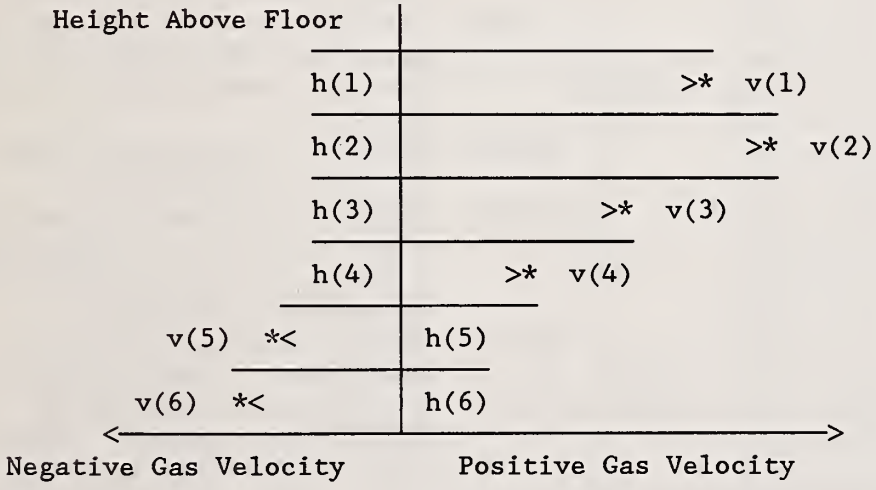
When only one velocity in the opening is known, the calculations are made assuming the same gas velocity over the whole area. However, when a velocity profile is used, the opening height is divided into segments calculated by the program and determined by the velocity probe positions. The flow rates for each part are calculated using the opening width, W (m), the segment height, h(i) (m), and the segment gas velocity, v(i) (m/s).

There are some conventions built in to the default flow coefficient conditions of this subroutine. In particular, the default flow coefficient for the positive direction corresponds to flows of relatively hot gas at relatively high velocities while the default flow coefficient for the negative direction corresponds to

flows of relatively cool gas at relatively low velocities. Thus the default conditions correspond to in = negative and out = positive.

The user is not restricted to these conventions; however, and may change them with the appropriate choices for the flow coefficients.

Note also that for comparison and plotting purposes, the absolute values of negative flow rates are returned. It is up to the user to decide the convention he wishes to use for in and out (-,+ or +,-). Note, however, that the negative value is stored in the first channel created and the positive value in the second.



Input	Variables	Format	Comments
HCb1	NPROBE,INP,IVF,IMF, IEF,HDOOR {,WDOOR} [,FCNEG [,FCPOS]] X	EVALU8 (NPDI [2])	Only one of these inputs is read each time the command FLOW-RATE is given. NPROBE - number of velocity channels to be used by this subroutine. Prepare NPROBE HCb2 inputs INP - the neutral plane height, m. = 0, do not store the result <> 0, store the result (1 channel created). IVF - the volume flow rate, m^3/s. = 0, do not store the result(s) = 1, store only the flows in the negative direction (1 channel created) = 2, store only the flows in the positive direction (1 channel created) = 3, store flows in both directions (2 channels created). IMF - the mass flow rate, kg/s. The values for IMF have the same function as IVF above. IEF - the convective energy flow rate, kW. The values for IEF have the same function as IVF above. HDOOR - height of instrumented door or other opening, m WDOOR - width of instrumented door or other opening, m. Enter this value only if IVF, IMF or IEF is greater than zero FCNEG - empirically derived flow coefficient, default = 0.68 FCPOS - empirically derived flow coefficient, default = 0.73 X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCb2	JVEL,POSJ {,CTEMP} {,JTEMP} {,JTEMP1, POSTC1,JTEMP2, POSTC2} [,CTAMB or ITAMB] X	EVALU8 (NPDI [2])	Information on all velocity probes used in above calculations. JVEL - velocity channel number, m/s (NPDI [3]). POSJ - position of probe relative to bottom of opening, m. CTEMP - temperature correction, °C. Enter this value only if a constant temperature correction is used. JTEMP - thermocouple channel number, °C. Enter this value only if the temperature correction is from a single, related thermocouple (NPDI [3]). JTEMP1 - the upper temperature channel number (by probe position) used in interpolation, °C (NPDI [3]). Enter this value only if using temperature interpolation POSTC1 - position of JTEMP1 relative to same origin as probe, m. Enter this value only if using temperature interpolation JTEMP2 - the lower temperature channel number (by probe position) used in interpolation, °C (NPDI [3]). Enter this value only if using temperature interpolation POSTC2 - position of JTEMP2 relative to same origin as probe, m. Enter this value only if using temperature interpolation CTAMB - ambient temperature, °C ITAMB - any integer value. The ambient temperature will be the first reading from whichever temperature method is used above.

			Note that if neither CTAMB nor ITAMB are entered, the current default value for the ambient temperature will be used (20 °C, unless redefined). X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.3 Part H, Class C, Subpart c: Input Specified by Complex Command GAS-FLOW

GAS-FLOW

The subroutine calculates the mass flow rate of a gas of known concentration, molecular weight, and velocity through an opening of known area. There are two methods of calculating the mass flow rate: one is for openings where only one gas concentration value is available and the other is where there is more than one value (vertical profile). Both use the same equation to calculate the mass flow rate:

$$M' = \frac{x(g) * W(g) * v(g) * A * T(amb) * p(amb)}{W(a) * T(g)}$$

where

M' - mass flow rate of gas, kg/s
x(g) - gas concentration expressed as a mole fraction
v(g) - gas velocity through opening, m/s
A - area of opening, m^2
T(amb) - ambient temperature, K
p(amb) - density of air at ambient temperature, kg/m^3
W(g), W(a) - molecular weight of gas and air
T(g) - gas temperature, K

When more than one gas probe are used (method 2), the opening is divided into segments, the sizes of which are governed by the positions of the probes. The

boundary between two probes is simply the halfway point. The total mass flow rate of the gas is the sum of the mass flow rates for the segments. Note that there is provision for the user to select segment sizes if desired.

The calculated values are stored in channels created by the program. This subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HCc1	ICALC, [CTAMB or JTAMB] X	EVALU8 (NPDI [2])	Only one set of these inputs is read each time the command GAS-FLOW is given. One channel is created for every HCc1 input read. ICALC - calculation type code = 1 - single segment opening. Prepare one HCc2 and one HCc3 input. = 2 - multi-segment opening. Prepare one HCc2 input, one HCc4 input, and one set of HCc5 inputs. CTAMB - constant ambient temperature, °C JTAMB - channel number of the ambient temperature (NPDI [3]), °C Note that if both CTAMB and JTAMB are left blank, the current default value for the ambient temperature will be used (20 °C, unless redefined). X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCc2	IGAS	A20	IGAS - a 20 character name for the kind of gas to be quantified

Input	Variables	Format	Comments
HCc3	JGAS,JVEL1,CTEMP or JTEMP1,AREA,AMWG X	EVALU8 (NPDI [2])	Read this input only if ICALC = 1. JGAS - gas concentration channel number, vol % (NPDI [3]) JVEL1 - gas velocity channel number, m/s (NPDI [3]) CTEMP - a constant associated temperature °C JTEMP1 - gas temperature channel number, °C (NPDI [3]) AREA - cross sectional area of opening m^2 AMWG - molecular weight of gas X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCc4	NGAS,HT,WD,JNP, ISMETH,AMWG X	EVALU8 (NPDI [2])	Read this input only if ICALC = 2. NGAS - number of gas probe locations. Prepare NGAS HCc5 inputs HT - height of opening parallel to line of probes, m WD - width of opening perpendicular to line of probes, m JNP - neutral plane height channel number, m (NPDI [3]) ISMETH = 1 - subroutine determines fixed segment heights based on gas probe positions (entered with input HCc5) = 2 - user supplies fixed segment heights (one for each gas probe). See SEGHT (input HCc5) AMWG - molecular weight of gas X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCc5	JGAS,GASPOS,IVMETH, ITMETH {,JVEL} {,JVEL1,VPOS1,JVEL2, VPOS2} {,CTEMP or JTEMP} {,JTEMP1, TPOS1,JTEMP2,TPOS2} {,SEGHT} X	EVALU8 (NPDI [2])	Read this input only if ICALC = 2. JGAS - gas concentration channel number, vol % (NPDI [3]) GASPOS - position of gas probe from bottom of opening, m IVMETH = 1 - use single associated velocity channel number = 2 - use velocity interpolation ITMETH = 1 - use single associated temperature channel number or constant temperature = 2 - use temperature channel interpolation JVEL - a single associated velocity channel number, m/s (NPDI [3]). Enter this value only if IVMETH = 1. JVEL1 - the upper velocity channel number (by probe position) used in interpolation, m/s (NPDI [3]). Enter this value only if IVMETH = 2. VPOS1 - position of JVEL1 from bottom of opening, m. Enter this value only if IVMETH = 2 JVEL2 - lower velocity channel number used in interpolation, m (NPDI [3]). Enter this value only if IVMETH = 2 VPOS2 - position of JVEL2 from bottom of opening, m. Enter this value only if IVMETH = 2 CTEMP - a constant associated temperature °C. Enter this value only if ITMETH = 1 JTEMP - a single associated temperature channel number, °C (NPDI [3]). Enter this value only if ITMETH = 1. JTEMP1 - the upper temperature channel number (by probe position) used in interpolation, °C (NPDI [3]). Enter this value only if ITMETH = 2. TPOS1 - position of JTEMP1 from bottom of opening, m. Enter this value only if ITMETH = 2

			JTEMP2 - lower temperature channel number used in interpolation, °C (NPDI [3]). Enter this value only if ITMETH = 2 TPOS2 - position of JTEMP2 from bottom of opening, m. Enter this value only if ITMETH = 2 SEGHT - user supplied height of segment associated with JGAS, m. Enter this value only if ISMETH > 1 (see input HCc4) X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.4 Part H, Class C, Subpart d: Input Specified by Complex Command HEAT-RATE

HEAT-RATE

The subroutine calculates the total rate of heat release for a system based on the oxygen depletion of the gas leaving the system[3]. There are five basic methods of calculating the rate of heat release. Some or all of the following input variables are required to make the calculations: oxygen, carbon dioxide, and carbon monoxide gas concentrations (volume percent), exhaust gas velocity (m/s), exhaust opening (doorway, window, stack, etc.) dimensions (m), neutral plane height (m), exhaust gas temperature (°C), input air volume flow rate (m^3/s), and input fuel volume flow rate (m^3/s).

The choice of method used to calculate the rate of heat release must be based on test conditions and available information. The five methods are:

1. open system - no restriction on air going into the test chamber; one oxygen concentration, one gas velocity, and one gas temperature measurement in the exhaust gas (from a single probe or from the average of several); the oxygen concentration may or may not be corrected for carbon dioxide concentration.

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[3] Parker, W. J., Calculations of the Heat Release Rate by Oxygen Consumption for Various Applications, Nat. Bur. Stand., (U. S.), NBSIR 81-2427-1 (March 1982).

2. the same type calculation as (1) except there are more than one oxygen concentration, gas velocity, and gas temperature measurement in the opening (i.e. a vertical profile of quantities). Essentially, the rate of heat release is calculated for each "segment" represented by an oxygen measurement, then added together to find the total rate of heat release.

3. open system - one oxygen, carbon dioxide, carbon monoxide, gas velocity, and gas temperature measurement; the fuel burning characteristics must be known, i.e. the stoichiometric coefficients of water, carbon dioxide, carbon monoxide, oxygen, and the fuel. The oxygen concentration is always corrected for carbon dioxide and carbon monoxide.

4. the same type calculation as (3) except there is a vertical profile as in type (2).

5. closed system - the input air and fuel are monitored and may be regulated; the outflow concentrations of oxygen, carbon dioxide, and carbon monoxide are known as are the stoichiometric coefficients of water, carbon dioxide, carbon monoxide, oxygen and fuel in the reaction equation.

Methods 1 and 2 use the same equation to calculate the rate of heat release:

$$Q' = \frac{dO2 * H * v * A * T(amb)}{T}$$

where

Q' - rate of heat release, kW

dO2 - oxygen depletion corrected for carbon dioxide concentration and expressed as a mole fraction =

$$\frac{0.209 - [x(O2) * 0.01 / (1.0 - x(CO2) * 0.01)]}{1.0 - (x(O2) * 0.01) / (1.0 - x(CO2) * 0.01)}$$

where x(O2) and x(CO2) are the oxygen and carbon dioxide concentrations, respectively, in volume percent. If the correction for carbon dioxide is not used, the equation for oxygen depletion reduces to

$$\frac{0.209 - x(O2) * 0.01}{1.0 - x(O2) * 0.01}$$

H - heat of combustion of fuel in terms of a volume of oxygen consumed at STP, kJ/m^3 (default value is 17010 kJ/m^3)

v - outflow gas velocity, m/s

A - opening area, m^2

T(amb) - ambient temperature, K

T - outflow gas temperature, K

Methods 3 and 4 use a different, more precise but more complex, equation to calculate the rate of heat release:

$$Q' = \frac{dO2 * H * v * A * T(amb)}{T * [1. + 0.209 * ((1. + a * dnu) / nu(O2))]}$$

where

Q' - rate of heat release, kW

dO2 - corrected oxygen depletion expressed as a mole fraction = 0.209 - x(O2) / (1. + gamma), where gamma = nu(H2O) * (x(CO2) + x(CO)) / (nu(CO2) + nu(CO))

x(O2), x(CO2), x(CO) - oxygen, carbon dioxide, and carbon monoxide concentrations expressed as mole fractions

dnu - difference in the sum of the stoichiometric coefficients of products and reactants, dnu = SUM[nu(p)] - SUM[nu(r)] = nu(H2O) + nu(CO2) + nu(CO) - nu(O2) - nu(f), where SUM is the summation function

nu(H2O), nu(CO2), nu(CO), nu(O2), nu(f) - stoichiometric coefficients of water, carbon dioxide, carbon monoxide, oxygen, and fuel in the reaction equation

H - heat of combustion of fuel in terms of a volume of oxygen consumed at STP, kJ/m^3 (default value is 17010 kJ/m^3)

v - outflow gas velocity, m/s

A - opening area, m^2

T(amb) - ambient temperature, K

T - outflow gas temperature, K

a - alpha, expansion factor for fraction of air depleted of oxygen. For x(O2) greater than zero, a=1. for x(O2) equal zero, a=-1./dnu

The calculation of the rate of heat release using method 5 rests heavily on the volume flow rates of air and fuel into the system and the oxygen concentration in the exhaust gas:

$$Q' = H * V(a) * [0.209 - (\frac{x(O2) * W(a)}{(1. + gamma) * W(g)} + \frac{V(f) * W(f)}{V(a) * W(a)})]$$

where

Q' - rate of heat release, kW
H - heat of combustion of fuel in terms of a volume of oxygen consumed at STP, kJ/m^3 (default value is 17010 kJ/m^3)
gamma - correction factor for oxygen,
gamma = nu(H2O) * (x(CO2) + x(CO)) / (nu(CO2) + nu(CO))
x(O2), x(CO2), x(CO) - oxygen, carbon dioxide, and carbon monoxide concentrations expressed as mole fractions
nu(H2O), nu (CO2), nu(CO) - stoichiometric coefficients of water, carbon dioxide, and carbon monoxide in the reaction equation
V(a), V(f) - temperature adjusted volume flow rate of air and fuel into the system, m^3/s
W(a), W(f), W(g) - molecular weight of input air, input fuel, and exhaust gas

When more than one oxygen probe are used (methods 2 and 4), the opening is divided into segments, the sizes of which are governed by the positions of the probes. The boundary between two probes is simply the halfway point. The total rate of heat release is then the sum of the rates of heat release for the segments. Note that there is provision for the user to select segment sizes if desired.

The calculated values are stored in their own channels created by the program. This subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HCd1	ICALC, [CTAMB or JTAMB] X	EVALU8 (NPDI [2])	Only one set of these inputs is read each time the command HEAT-RATE is given. One channel is created for every HCd1 input read. ICALC - calculation type code = 1 - single-segment opening, uncorrected oxygen (or oxygen corrected for carbon dioxide only). Prepare one HCd2 input. = 2 - multi-segment opening, uncorrected oxygen (or oxygen corrected for carbon dioxide only). Prepare one HCd3 input and one set of HCd4 inputs. = 3 - single-segment opening, oxygen corrected for carbon dioxide and carbon monoxide and considering fuel burning characteristics. Prepare one HCd5 and one HCd6 input. = 4 - multi-segment opening, oxygen corrected for carbon dioxide and carbon monoxide and considering fuel burning characteristics. Prepare one HCd5 input, one HCd7 input, and one set of HCd8 inputs. = 5 - closed system, input air and fuel monitored, exhaust oxygen corrected for carbon dioxide and carbon monoxide and considering fuel burning characteristics. Prepare one HCd5 input and one HCd9 input. CTAMB - a constant ambient temperature, °C. JTAMB - channel number of the ambient temperature, °C (NPDI [3]).

			Note that if both CTAMB and JTAMB are left blank, the current default value for the ambient temperature will be used (20 °C, unless redefined). X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCd2	JO2,JVEL1,CTEMP or JTEMP,AREA,ICORR {,JCORR} [,HCOM] X	EVALU8 (NPDI [2])	Read this input only if ICALC = 1. JO2 - oxygen concentration channel number, vol % (NPDI [3]) JVEL1 - velocity channel number, m/s (NPDI [3]) CTEMP - a constant associated temperature, °C. Enter this value only if a constant temperature correction is used. JTEMP - temperature channel number (NPDI [3]) °C. Enter this value only if the temperature correction is from a related thermocouple. AREA - cross sectional area of opening (m^2) ICORR = 0 - no carbon dioxide correction of oxygen depletion for rate of heat release calculation > 0 - make carbon dioxide correction JCORR - carbon dioxide concentration channel number for carbon dioxide correction of oxygen depletion (NPDI [3]). Enter this value only if ICORR > 0 HCOM - average heat of combustion of fuel expressed in terms of a unit volume of oxygen consumed at STP (kJ/m^3). Enter this value only if the default value needs to be changed. The default value is 17010. kJ/m^3 (average for many common fuels) X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCd3	NO2,HT,WD,JNP, ISMETH,ICORR [,HCOM] X	EVALU8 (NPDI [2])	Read this input only if ICALC = 2. NO2 - number of oxygen probe locations. Prepare NO2 HCd4 input(s) HT - height of opening parallel to line of probes, m WD - width of opening perpendicular to line of probes, m JNP - neutral plane height channel number, m (NPDI [3]) ISMETH = 1 - subroutine determines fixed segment heights based on gas probe positions (entered with input HCd4) > 1 - user supplies fixed segment heights, m (one for each gas probe). See SEGHT (input HCd4) ICORR = 0 - no carbon dioxide correction of oxygen depletion for rate of heat release calculation > 0 - make carbon dioxide correction HCOM - average heat of combustion of fuel expressed in terms of a unit volume of oxygen consumed at STP (kJ/m^3). Enter this value only if the default value needs to be changed. The default value is 17010. kJ/m^3 (average for many common fuels) X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCd4	JO2,O2POS,IVMETH, ITMETH {,JVEL} {,JVEL1,VPOS1,JVEL2, VPOS2} {,CTEMP or JTEMP} {,JTEMP1, TPOS1,JTEMP2,TPOS2} {,SEGHT} {,JCORR} X	EVALU8 (NPDI [2])	Read this input only if ICALC = 2. JO2 - oxygen concentration channel number, vol % (NPDI [3]) O2POS - position of oxygen probe from bottom of opening, m IVMETH = 1 - use single associated velocity channel number = 2 - use velocity channel interpolation

ITMETH = 1 - use single associated temperature channel number or constant temperature
= 2 - use temperature channel interpolation

JVEL - a single associated velocity channel number, m/s (NPDI [3]). Enter this value only if IVMETH = 1.

JVEL1 - the upper velocity channel (by position) used in interpolation m/s (NPDI [3]). Enter this value only if IVMETH = 2.

VPOS1 - position of JVEL1 from bottom of opening, m. Enter this value only if IVMETH = 2

JVEL2 - lower velocity channel number used in interpolation, m (NPDI [3]). Enter this value only if IVMETH = 2

VPOS2 - position of JVEL2 from bottom of opening, m. Enter this value only if IVMETH = 2

CTEMP - a constant associated temperature, °C. Enter this value only if ITMETH = 1

JTEMP - a single associated temperature channel number, °C (NPDI [3]). Enter this value only if ITMETH = 1.

JTEMP1 - upper temperature channel channel number (by position) used in interpolation, °C (NPDI [3]). Enter this value only if ITMETH = 2.

TPOS1 - position of JTEMP1 from bottom of opening, m. Enter this value only if ITMETH = 2

JTEMP2 - lower temperature channel number used in interpolation, °C (NPDI [3]). Enter this value only if ITMETH = 2

TPOS2 - position of JTEMP2 from bottom of opening, m. Enter this value only if ITMETH = 2

SEGHT - user supplied height of segment associated with JGAS, m. Enter this value only if ISMETH > 1 (see input HCd3)

			JCORR - carbon dioxide concentration channel number for carbon dioxide correction of oxygen depletion (NPDI [3]). Enter this value only if ICORR > 0 see input HCd3) X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCd5	VH2O,VCO2,VCO, VO2,VF [,HCOM] X	EVALU8 (NPDI [2])	Read this input only if ICALC = 3, 4 or 5. VH2O - stoichiometric coefficient of water in the reaction VCO2 - coefficient of carbon dioxide VCO - coefficient of carbon monoxide VO2 - coefficient of oxygen VF - coefficient of the fuel HCOM - average heat of combustion of fuel expressed in terms of a unit volume of oxygen consumed at STP (kJ/m^3). Enter this value only if the default value needs to be changed. The default value is 17010. kJ/m^3 (average for many common fuels) X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCd6	JO2,JCO2,JCO,JVEL, CTEMP or JTEMP, AREA X	EVALU8 (NPDI [2])	Read this input only if ICALC = 3. JO2 - oxygen concentration channel number, vol % (NPDI [3]) JCO2 - carbon dioxide concentration channel number, vol % (NPDI [3]) JCO - carbon monoxide concentration channel number, vol % (NPDI [3]) JVEL - velocity channel number, m/s (NPDI [3]) CTEMP - a constant associated temperature, °C JTEMP - temperature channel number, °C (NPDI [3]) AREA - cross sectional area of opening, m^2 X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCd7	NO2,HT,WD,JNP, JAVFRI,JAVFRO,CATI or JATI,CATO or JATO,WF,ISMETH X	EVALU8 (NPDI [2])	Read this input only if ICALC = 4. NO2 - number of oxygen probe locations. Prepare NO2 HCd8 input(s) HT - height of opening parallel to line of probes, m WD - width of opening perpendicular to line of probes, m JNP - neutral plane height channel number, m (NPDI [3]) JAVFRI - volume flow rate of gas going into chamber channel number, m^3/s (NPDI [3]) JAVFRO - volume flow rate of gas coming out of chamber channel number, m^3/s (NPDI [3]) CATI - constant temperature of air going into opening, °C JATI - average temperature of air going into opening channel number (NPDI [3]) CATO - constant temperature of air coming out of opening, °C JATO - average temperature of gas coming out of opening channel number (NPDI [3]) WF - molecular weight of the fuel ISMETH = 1 - subroutine determines fixed segment heights based on gas probe positions (entered with input HCd8) > 1 - user supplies fixed segment heights (one for each gas probe). See SEGHT (input HCd8) X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCd8	JO2,JCO2,JCO,GASPOS, IVMETH,ITMETH {,JVEL} {,JVEL1,VPOS1,JVEL2, VPOS2} {,CTEMP or JTEMP} {,JTEMP1, TPOS1,JTEMP2,TPOS2} {,SEGHT} X	EVALU8 (NPDI [2])	Read this input only if ICALC = 4. JO2 - oxygen concentration channel number, vol % (NPDI [3]) JCO2 - carbon dioxide concentration channel number, vol % (NPDI [3]) JCO - carbon monoxide concentration channel number, vol % (NPDI [3])

GASPOS - position of gas probe from bottom of opening, m

IVMETH = 1 - use single associated velocity channel number

= 2 - use velocity interpolation

ITMETH = 1 - use single associated temperature channel number or constant temperature

= 2 - use temperature channel interpolation

JVEL - a single associated velocity channel number, m/s (NPDI [3]). Enter this value only if IVMETH = 1.

JVEL1 - the upper velocity channel number (by probe position) used in interpolation, m/s (NPDI [3]). Enter this value only if IVMETH = 2.

VPOS1 - position of JVEL1 from bottom of opening, m. Enter this value only if IVMETH = 2

JVEL2 - lower velocity channel number used in interpolation, m (NPDI [3]). Enter this value only if IVMETH = 2

VPOS2 - position of JVEL2 from bottom of opening, m. Enter this value only if IVMETH = 2

CTEMP - a constant associated temperature °C. Enter this value only if ITMETH = 1

JTEMP - a single associated temperature channel number (NPDI [3]). Enter this value only if ITMETH = 1.

JTEMP1 - the upper temperature channel number (by probe position) used in interpolation, °C (NPDI [3]). Enter this value only if ITMETH = 2.

TPOS1 - position of JTEMP1 from bottom of opening, m. Enter this value only if ITMETH = 2

JTEMP2 - lower temperature channel number used in interpolation, °C (NPDI [3]). Enter this value only if ITMETH = 2

TPOS2 - position of JTEMP2 from bottom of opening, m. Enter this value only if ITMETH = 2

			SEGHT - user supplied height of segment associated with JGAS, m. Enter this value only if ISMETH > 1 (see input HCd7) X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCd9	JO2,JCO2,JCO,JVFF, JVFA,WF,CTF or JTF, CTA or JTA X	EVALU8 (NPDI [2])	Read this input only if ICALC = 5. JO2 - oxygen concentration channel number, vol % (NPDI [3]) JCO2 - carbon dioxide concentration channel number, vol % (NPDI [3]) JCO - carbon monoxide concentration channel number, vol % (NPDI [3]) JVFF - fuel volume flow rate channel number, m^3/s (NPDI [3]) JVFA - air volume flow rate channel number, m^3/s (NPDI [3]) WF - molecular weight of fuel CTF - a constant fuel temperature, °C JTF - fuel temperature channel number (NPDI [3]), °C CTA - a constant air temperature, °C JTA - air temperature channel number (NPDI [3]), °C X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.5 Part H, Class C, Subpart e: Input Specified by Complex Command HEAT-RATE-2

HEAT-RATE-2

The subroutine calculates the total rate of heat release for a system based on the oxygen depletion and mass flow rate of exhaust gases through an exhaust duct or other exhaust collection device. For the best results, the specific energy and the stoichiometric factor for the fuel being burned should be known. The default values for these parameters are 13100. kJ/kg and 1.5, respectively.

The rate of heat release equation is then

$$Q' = S * \frac{M(O2)}{M(air)} * m' * X$$

where,

- Q' - rate of heat release, kW
- S - specific energy (S = dhc/r0), kJ/kg (default = 13100.)
  - dhc - net heat of combustion, kJ/kg
  - r0 - stoichiometric oxygen/fuel mass ratio
- M(O2) - molecular weight of oxygen (= 32.)
- M(air) - molecular weight of air (= 28.97)
- m' - mass flow rate of gases through collection duct, kg/s

and,

$$X = \frac{1}{[(1 - XO2 - XCO2) / (XO2(0) * (1 - XCO2) - XO2 * (1 - XCO2(0)))] + (b-1)}$$

XO2(0) - baseline oxygen concentration, as a fraction
XO2 - oxygen concentration, as a fraction
XCO2(0) - baseline carbon dioxide concentration, as a fraction
XCO2 - carbon dioxide concentration, as a fraction
b - stoichiometric factor, dimensionless (default = 1.5)

The calculated values are stored in their own channels created by the program. One channel is created each time the command HEAT-RATE-2 is given. This subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HCel	JO2,CMFR or JMFR, ICO2 {,JCO2} [[,B],SENRGY] X	EVALU8 (NPDI [2])	JO2 - oxygen concentration channel number (NPDI [3]), vol %. CMFR - an arbitrary, constant mass flow rate, kg/s. JMFR - a mass flow rate channel number (NPDI [3]), kg/s. ICO2 = 0, no carbon dioxide correction > 0, oxygen corrected for carbon dioxide JCO2 - the carbon monoxide concentration channel number, volume %, used to correct the oxygen concentration (NPDI [3]). Enter this value only if ICO2 > 0. B - stoichiometric factor, dimensionless. (Default = 1.5) SENRGY - specific energy, kJ/kg. (Default = 13100.) X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.6 Part H, Class C, Subpart f: Input Specified by Complex Command HOT/COLD

HOT/COLD

The subroutine finds the height of the hot/cold interface and the average temperatures above and below the interface using a temperature profile of the gas[4].

The temperature at the interface is defined to be:

$$Ti = Tl + ((Th - Tl) * C)$$

where,

- Ti - the temperature at the interface height
- Tl - the lowest temperature in the profile; (this subroutine uses the temperature of the bottom thermocouple in the profile)
- Th - the highest temperature in the profile.
- C - an empirical value, less than or equal to 1.0, used to define the temperature at the interface height

Once the temperature at the interface height is known, the height of the interface is found by interpolating between the pair of profile temperatures that

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[4] Cooper, L. Y., Harkleroad, M., Quintiere, J. G., and Rinkinen, W. J., An Experimental Study of Upper Hot Layer Stratification in Full-Scale Multiroom Fire Scenarios, J. Heat Trans., Vol. 104, 741-749 (November 1982).

bracket the interface temperature. Note that you may request the program to calculate (by extrapolation) the temperature at height = 0.0 and that that temperature and position are than available to the algorithm for finding the interface height.

Once the interface height is known, the average temperatures above and below it are calculated.

The calculated interface height, average upper gas temperature, and average lower gas temperature are stored in channels created by the program, at the option of the user. This subroutine does not reduce any raw data. Any units may be used for temperature and position as long as they are consistent among themselves. Only one set of HCf inputs is read each time the command HOT/COLD is given.

Input	Variables	Format	Comments
HCf1	IHT;IHOT,ICOLD, ROOMHT, [IXTRAP,] [PCT] X	EVALU8 (NPDI [2])	IHT > 0 - store the calculated interface height. One channel is created. IHOT > 0 - store the calculated temperature of the gases above the interface ICOLD > 0 - store the calculated temperature of the gases below the interface ROOMHT - the height of the ceiling at the point in line with the temperature profile IXTRAP > 0 - calculate temperature at HEIGHT = 0.0 by extrapolation of the bottom two thermocouples. PCT - the temperature at the interface height is defined as Tc + (Th - Tc) * (IPCT/100). The default value is 20. X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCf2	JTEMP(1),JTEMP(2), ...,JTEMP(i) X 1 <= i <= 25	EVALU8 (NPDI [2])	JTEMP - thermocouple channel number (NPDI [3]). Thermocouples may be in any order. The positions, entered with data input HCf3 below, must be in the same order. X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCf3	POS(1),POS(2),..., POS(i) X 1 <= i <= 25	EVALU8 (NPDI [2])	POS - height of the thermocouple in the corresponding position on data input HCf2. X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.7 Part H, Class C, Subpart g: Input Specified by Complex Command MASS-FLOW

MASS-FLOW

The subroutine calculates the height of the neutral plane from the temperature profile at the room opening and one static pressure probe and the mass flow rate of hot gas in and out of the fire room based only on the gas temperature and opening dimensions[5] [6]

The neutral plane is found by solving the following equation for "Hnp":

$$dP + g * rho * SUM [(1. - (Ta/T)) * dH] = 0.0$$

where,

dP: pressure (Pa) at an arbitrarily chosen height, "Hp" (m)
g: acceleration due to gravity = 9.8 m/s^2
rho: density of air (kg/cu m) at temperature "Ta"
Ta: absolute ambient temperature (K)
T: absolute temperature (K) at some height, "H" (m), in interior of room, where Hp <= H <= Hnp

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[5] Lee, B. T., Effect of Ventilation on the Rates of Heat, Smoke, and Carbon Monoxide Production in A Typical Jail Cell Fire, Nat. Bur. Stand., (U. S.), NBSIR 82-2469 (March 1982).

[6] Lee, B. T., Effect of Wall and Room Surfaces on the Rates of Heat, Smoke, and Carbon Monoxide Production in A Park Lodging Bedroom Fire, Nat. Bur. Stand., (U. S.), NBSIR 85-2998 (February 1985).

dH: segment height (m), which is at most twice the accuracy of the calculation
SUM: the summation function over the range Hp to Hnp by dH
Hnp: the neutral plane height (m)

Once the neutral plane height is calculated, the mass flow rates are calculated using the following equation:

$$Mdot = C*W*rho*Ta*SQRT(2g) * SUMd [SQRT(1/Td * SUMi [(1/Ta - 1/Ti) * dHi]) * dHd]$$

where,

Mdot: mass flow rate (kg/s)
C: flow coefficient; defaults are 0.68 for inflow and 0.73 for outflow
W: the width of the opening (m)
rho: density of air (kg/cu m) at temperature "Ta"
Ta: absolute ambient temperature (K)
g: acceleration due to gravity = 9.8 m/s^2
SQRT: the square root function
dHd: segment height in doorway (m)
Td: absolute temperature (K) at some height, "H" (m) in doorway
Ti: absolute temperature (K) at some height, "H" (m) in interior
dHi: segment height in interior (m)
SUMd: the summation function over the range
Hnp to zero by -dHd for in-flow and
Hnp to Hdoor by dHd for out-flow
SUMi: the summation function over the range
Hnp to H by -dHi for in-flow and
Hnp to H by dHi for out-flow
Hdoor: the height of the opening (m)
Hnp: the height of the neutral plane (m)

The results are stored in channels created by the program. This subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HCg1	WDOOR,HDOOR,HINT, INP,IMFI,IMFO, CPR or JPR,PPR, CTAMB or JTAMB, [,FCI [,FCO [,HACC]]] X	EVALU8 (NPDI [2])	WDOOR - width of opening, m. HDOOR - height of opening, m. HINT - height of interior, m. INP <> 0 - save the neutral plane heights calculated. One channel is created. IMFI <> 0 - calculate and save the mass flow rate into room. One channel is created. IMFO <> 0 - calculate and save the mass flow rate out of room. One channel is created. CPR - constant static pressure, Pa. JPR - static pressure channel number Pa (NPDI [3]). PPR - position of static pressure measurement above floor, m. CTAMB - constant ambient temperature, °C. JTAMB = 0 - use default ambient temperature > 0 - temperature channel of temperature to be used as ambient (NPDI [3]). FCI - flow coefficient for flows going into room (default = 0.68) FCO - flow coefficient for flows going out of room (default = 0.73) HACC - accuracy of the neutral plane calculation, m (default = 0.01) X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCg2	JTCD(1),JTCD(2),..., JTCD(i) X 1 <= i <= 50	EVALU8 (NPDI [2])	JTCD - doorway thermocouple channel number, °C (NPDI [3]). X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCg3	PD(1),PD(2),..., PD(i) X 1 <= i <= 50	EVALU8 (NPDI [2])	PD - doorway thermocouple positions (height above floor) of above thermocouples in same order, m. X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCg4	JTCI(1),JTCI(2),..., JTCI(i) X 1 <= i <= 50	EVALU8 (NPDI [2])	JTCI - interior thermocouple channel number, °C (NPDI [3]). X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCg5	PI(1),PI(2),..., PI(i) X 1 <= i <= 50	EVALU8 (NPDI [2])	PI - interior thermocouple positions (height above floor) of above thermocouples in same order, m. X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.8 Part H, Class C, Subpart h: Input Specified by Complex Command MASS-FLOW-2

MASS-FLOW-2

The subroutine is very similar to the one used for the command MASS-FLOW, except that the neutral plane height is an input value instead of a calculated value. The mass flow rate of gas in and out of the fire room is still based on the gas temperature and the opening dimensions.

The mass flow rates are calculated using the following equation:

Mdot = C*W*rho*Ta*SQRT(2g) * SUMd [SQRT(1/Td * SUMi [(1/Ta - 1/Ti) * dHi]) * dHd]

where,

Mdot:	mass flow rate (kg/s)
C:	flow coefficient; defaults are 0.68 for inflow and 0.73 for outflow
W:	the width of the opening (m)
rho:	density of air (kg/cu m) at temperature "Ta"
Ta:	absolute ambient temperature (K)
g:	acceleration due to gravity = 9.8 m/s^2
SQRT:	the square root function
dHd:	segment height in doorway (m)
Td:	absolute temperature (K) at some height, "H" (m) in doorway
Ti:	absolute temperature (K) at some height, "H" (m) in interior
dHi:	segment height in interior (m)
SUMd:	the summation function over the range Hnp to zero by -dHd for in-flow and Hnp to Hdoor by dHd for out-flow

SUMi: the summation function over the range
Hnp to H by -dHi for in-flow and
Hnp to H by dHi for out-flow
Hdoor: the height of the opening (m)
Hnp: the height of the neutral plane (m)

The results are stored in channels created by the program. This subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HChl	WDOOR,HDOOR,HINT,CNP or JNP,IMFI,IMFO, CTAMB or JTAMB, [,FCI [,FCO [,HACC]]] X	EVALU8 (NPDI [2])	WDOOR - width of opening, m. HDOOR - height of opening, m. HINT - height of interior, m. CNP - constant neutral plane height, m. JNP - neutral plane height channel number, m (NPDI [3]). IMFI > 0 - calculate and save the mass flow rate into room. One channel is created. IMFO > 0 - calculate and save the mass flow rate out of room. One channel is created. CPR - constant static pressure, Pa. JPR - static pressure channel number, Pa (NPDI [3]). PPR - position of static pressure measurement above floor, m. CTAMB - constant ambient temperature, °C. JTAMB = 0 - use default ambient temperature > 0 - temperature channel of temperature to be used as ambient (NPDI [3]). FCI - flow coefficient for flows going into room (default = 0.68)

			FCO - flow coefficient for flows going out of room (default = 0.73) HACC - accuracy of the neutral plane calculation, m (default = 0.01) X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCh2	JTCD(1),JTCD(2),..., JTCD(i) X 1 <= i <= 50	EVALU8 (NPDI [2])	JTCD - doorway thermocouple channel number, °C (NPDI [3]). X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCh3	PD(1),PD(2),..., PD(i) X 1.<= i <= 50	EVALU8 (NPDI [2])	PD - doorway thermocouple positions (height above floor) of above thermocouples in same order, m. X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCh4	JTCI(1),JTCI(2),..., JTCI(i) X 1 <= i <= 50	EVALU8 (NPDI [2])	JTCI - interior thermocouple channel number, °C (NPDI [3]). X = ' X' - end-of-set mark
Input	Variables	Format	Comments
HCh5	PI(1),PI(2),..., PI(i) X 1 <= i <= 50	EVALU8 (NPDI [2])	PI - interior thermocouple positions (height above floor) of above thermocouples in same order, m. X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.9 Part H, Class C, Subpart i: Input Specified by Complex Command MASS-FLOW-3

MASS-FLOW-3

The subroutine calculates the mass flow rate of gas through an opening where the gas flow is in only one direction and the velocity, temperature, and area perpendicular to the flow are known. It is particularly well suited for calculations in an exhaust duct.

The equation for the mass flow rate is

$$m' = c * V * A * rho * (Ta/T)$$

where,

- m' - mass flow rate of gas, kg/s
- c - empirical flow coefficient, default = 1.0
- V - gas velocity, m/s
- A - cross sectional area of the duct (perpendicular to the direction of gas flow, m^2
- rho - density of air at temperature "Ta", kg/m^3
- Ta - absolute ambient temperature, default = 293.15 K (20 C)
- T - absolute temperature of gas, K

The calculated results are stored in a channel created by the program. One channel is created each time the command MASS-FLOW-3 is given. The subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HCi1	JVEL,AREA,JTEMP or CTEMP [,C [,CTAMB or JTAMB]] X	EVALU8 (NPDI [2])	JVEL - gas velocity channel number, (NPDI [3]) m/s. AREA - cross sectional area of the exhaust duct perpendicular to the gas flow, m^2. JTEMP - gas temperature channel number, °C (NPDI [3]). CTEMP - an arbitrary constant gas temperature, °C. C - an empirical flow coefficient. (Default = 1.0) CTAMB - an arbitrary constant ambient temperature, °C. JTAMB - an ambient temperature channel number, °C (NPDI [3]). Note that if both CTAMB and JTAMB are left blank, the current default value for the ambient temperature will be used (20 °C, unless redefined). X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.10 Part H, Class C, Subpart j: Input Specified by Complex Command STATIC

STATIC

The subroutine uses static pressure measurements in conjunction with some other test parameters, such as temperature, to calculate various quantities of interest.

Generally, if more than one probe is used they are arranged such that a pressure "profile" of the room from top to bottom can be ascertained. In addition, the profile makes it possible to calculate gas velocities through openings in the chamber, the neutral plane and thermal discontinuity heights in the openings, and the interior gas temperature in the chamber.

The standard unit for pressure is the pascal (Pa). The calculated velocities, heights, and temperatures are in meters per second (m/s), meters (m), and degrees Celsius (°C), respectively.

Gas Velocities

The gas velocity, v (m/s), through an opening at a given height, z (m), can be

calculated from the static pressure at height z and the average local gas temperature:

$$v(z) = (2 * dP(z) / p(z)) ** .5$$

where dP(z) is the pressure difference at height z with respect to ambient static pressure (Pa) and p(z) is the density of the gas (kg/m^3) at height z. Using the gas law:

$$p(z) = p(0) * T(0) / T(z)$$

where T(z) is the absolute average local temperature (K) and p(0) and T(0) are constant, arbitrarily chosen gas density and temperature (p(0) = 1.197 kg/m^3, T(0) = 295 (K). The velocity equation then becomes

$$v = [2 * T(z) * dP(z) / (p(0) * T(0))] ** .5$$
$$= .07526 * (T(z) * dP(z)) ** .5$$

Neutral Plane and Thermal Discontinuity Heights

To find the neutral plane and thermal discontinuity heights from the static pressure "profile", two least square straight lines are found: one for the probes above the neutral plane (positive pressure difference with ambient), one for the probes below the neutral plane (negative pressure difference with ambient). The Y-axis intercept for the former yields the neutral plane height;

the intersection of the two yields the thermal discontinuity height. In addition, once the thermal discontinuity height is found, the first equation can be rearranged and evaluated to find the static pressure at that height.

The equations for the two lines are of the form:

$$z = a * dP + b \quad \text{and}$$

$$z' = c * dP' + d$$

where z and z' are the heights above the floor and dP and dP' are the pressure differences with respect to ambient static pressure at those heights.

The equations for the coefficients are:

$$a = \frac{n * SUM[dP(i)*z(i),i=1,n] - SUM[dP(i),i=1,n] * SUM[z(i),i=1,n]}{n * SUM[dP(i)**2,i=1,n] - SUM[dP(i),i=1,n] ** 2}$$

$$b = \frac{SUM[z(i),i=1,n] - a * SUM[dP(i),i=1,n]}{n}$$

$$c = \frac{n' * SUM[dP'(i)*z'(i),i=1,n'] - SUM[dP'(i),i=1,n'] * SUM[z'(i),i=1,n']}{n' * SUM[dP'(i)**2,i=1,n'] - SUM[dP'(i),i=1,n'] ** 2}$$

$$d = \frac{SUM[z'(i),i=1,n'] - c * SUM[dP'(i),i=1,n']}{n'}$$

where n and n' are the number of probes above and below the neutral plane, respectively, and SUM is the summation function. The neutral plane height,

z(np), equals b. The thermal discontinuity height occurs at the height where dP = dP' = dP(td) and z = z' = z(td). Then, solving the two equations,

$$z(td) = a * dP(td) + b \quad \text{and}$$

$$z(td) = c * dP(td) + d$$

simultaneously for the thermal discontinuity height yields

$$z(td) = \frac{(b * c) - (a * d)}{(c - a)}$$

Rearranging the first equation and evaluating at height z(td) yields the pressure at the thermal discontinuity height:

$$z(td) = a * dP(td) + b$$

$$dP(td) = b * z(td) / a$$

Interior Gas Temperatures

The interior gas temperature T (°C) at a given height z is calculated from the difference in pressure between height z and the thermal discontinuity height and the difference in position between the two heights.

$$T(z) = \frac{T(amb)}{1 - (DP / (G * p(amb) * DZ))} - 273.15$$

where DP = dP(z) - dP(td), DZ = z - z(td), G is the acceleration due to gravity (= 9.806 m/s^2), and T(amb) and p(amb) are the ambient gas temperature (K) and density (kg/m^3).

The calculated values are stored in channels created by the program. This subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HCj1	NPROBE,IVEL {,JTAVG}, INPTD {,HEIGHT}, ITEMP [,CTAMB or JTAMB] X	EVALU8 (NPDI [2])	NPROBE - number of static pressure probes in this profile. Prepare NPROBE HCj2 inputs. IVEL = 0 - no calculations made > 0 - calculate air velocity through opening from interior static pressure for each probe. NPROBE channels will be created. JTAVG - average interior upper air temperature channel, °C (NPDI [3]). Enter this value only if IVEL > 0. INPTD = 0 - no calculations > 0 - calculate the positions of the neutral plane and thermal discontinuity and the static pressure at the thermal discontinuity height. 3 channels will be created. HEIGHT - opening height, m. Enter this value only if INPTD > 0. ITEMP = 0 - no calculations made > 0 - calculate the interior gas temperature near each probe. NPROBE channels will be created. ITEMP may only be > 0 if INPTD > 0. CTAMB - a constant ambient temperature, °C. JTAMB - channel number of the ambient temperature (NPDI [3]), °C. Note that if both CTAMB and JTAMB are left blank, the current default value for the ambient temperature will be used (20 °C, unless redefined). The ambient temperature is not required if IVEL=0 and ITEMP=0. X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HCj2	JCHAN,POS {,JTOPEN} X	EVALU8 (NPDI [2])	JCHAN - static pressure channel number, Pa (NPDI [3]). POS - position of probe relative to floor, m. JTOPEN - corresponding opening thermocouple channel (NPDI [3]) Enter this value only if IVEL > 0 (see input HCj1). X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.11 Part H, Class C, Subpart k: Input Specified by Complex Command SURFACE

SURFACE

The subroutine calculates the average and total heat loss rate and the incident heat flux to a semi-infinite surface (such as a wall or ceiling) from the surface temperature and material characteristics[7]. The three equations are related to each other and are as follows:

$$q(a,j) = k/2 * (pi/a)^{**}0.5 * \frac{(T - T(0))}{(t(j) - t(j-1))^{**}0.5} -$$

$$SUM[q(a,i) * ((t(j) - t(i-1))^{**}0.5 - (t(j) - t(i))^{**}0.5), i=1,j-1]$$

$$q(t,j) = q(a,j) * A$$

$$q(j) = q(a,j) + e * s * (T^{**}4)$$

where

q(a,j) - average heat loss rate per unit area, kW/m^2, at time step j
q(t,j) - total heat loss rate, kW, at time step j
q(j) - incident heat flux, kW/m^2, at time step j
k - thermal conductivity of surface, kW/m * °C
pi - ratio of the radius squared to the area of a circle = 3.14159
a - alpha, thermal diffusivity of the surface material, m^2/s
T(0) - initial surface temperature, K

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[7] Fang, J. B., and Breese, J. N., Fire Development in Residential Basement Rooms, Nat. Bur. Stand., (U. S.), NBSIR 80-2120 (October 1980).

T - surface temperature, K
t(j) - time at step j, s
A - surface area, m^2
e - epsilon, total emissivity of surface, dimensionless
s - sigma, Stefan-Boltzmann constant,
= 5.667 * 10.**-11 kW / (m^2 * K^4)

All three calculations are made at the same time and each is stored in its own channel created by the program. This subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HCkl	IWTYPE,AREA,CTEMP or JTEMP,JTIME {,TCONA, TCONB,ALPHA,EPSIS}, IAHLR,ITHLR,ITNHF [,CTAMB or JTAMB] X	EVALU8 (NPDI [2]	IWTYPE - wall material type code = 1 - plywood = 2 - concrete block = 3 - gypsum board (default) = 4 - acoustic tile = 5 - ceramic board = 6 - kaowool = 0 - any user defined material (thermal characteristics entered below) AREA - total surface area, m^2 CTEMP - constant surface temperature, °C JTEMP - temperature channel number (single or average), °C (NPDI [3]) JTIME - reference time channel number, s TCONA,TCONB - the thermal conductivity of a material varies with temperature. TCONA and TCONB are variables in the straight line definition of the thermal conductivity = TCONA + TCONB * T, where T is the material temperature (°C). For temperatures less than 260 °C, the conductivity is assumed the same as at 260 °C. Enter these values only if IWTYPE = 0

			ALPHA - thermal diffusivity of surface material not in list, m^2/s. Enter this value only if IWTYPE = 0 EPSIS - total emissivity of surface material not in list. Enter this value only if IWTYPE = 0 IAHLR > 0 - save the calculated values of the average rate of heat loss. One channel created ITHLR > 0 - save the calculated values of the total heat loss. One channel created. ITNHF > 0 - save the calculated values of the incident heat flux. One channel created. CTAMB - a constant ambient temperature, °C JTAMB = 0 - use CTEMP or the first reading from channel JTEMP, whichever is used > 0 - the ambient temperature channel number (NPDI [3]). Note that if neither CTAMB nor JTAMB are used, the default ambient temperature is used. (See AMBIENTS command) X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.12 Part H, Class C, Subpart 1: Input Specified by Complex Command VENT-LOSS

VENT-LOSS

The subroutine calculates the radiative heat loss rate through an opening based on the temperature in the opening. The equation is as follows:

```
Q' = s * e * A * (T**4 - T(amb)**4)
```

where

```
     Q' - rate of heat loss, kW
      s - sigma, Stefan-Boltzmann constant,
          = 5.667 * 10.**-11 kW / (m^2 * K^4)
      e - epsilon, emissivity of hot gas containing carbon dioxide, water
          vapor and smoke, dimensionless (assumed = 1.0)
      A - area of opening, m^2
 T(amb) - ambient temperature, K
      T - gas temperature, K
```

If a temperature profile is used (i.e. more than one thermocouple in the opening), the opening is divided into segments. The heat loss rate for each segment is calculated and added together to get the total.

The calculated results are stored in a channel created by the program. This subroutine does not reduce any raw data.

Input	Variables	Format	Comments
HC11	OPENWD,OPENHT, [CTAMB or JTAMB] X	EVALU8 (NPDI [2])	One channel is created each time the command VENT-LOSS is given. OPENWD - width of the opening perpendicular to the string of thermocouples, m OPENHT - height of the opening parallel to string of thermocouples, m CTAMB - a constant ambient temperature, °C. JTAMB - channel number of the ambient temperature (NPDI [3]), °C. Note that if both CTAMB and JTAMB are left blank, the current default value for the ambient temperature will be used (20 °C, unless redefined). X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HC12	JTEMP(i) X 1 <= i <= 30	EVALU8 (NPDI [2])	JTEMP - single or average temperature channel number, °C (NPDI [3]) X = ' X' - end-of-set mark

Input	Variables	Format	Comments
HC13	TMPLOC(j) X 2 <= j <= i	EVALU8 (NPDI [2])	Enter this input only if 2 or more temperature channels were entered above. TMPLOC - the height of the temperature reading (m) of the above in the same order X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.13 Part H, Class C, Subpart m: Input Specified by Complex Command WT-RATE

WT-RATE

The subroutine makes two different calculations based on the total weight loss of an item: percent weight loss and rate of weight loss. Each of the calculations can be called individually. The calculated results are stored in their own channels created by the program. This subroutine does not reduce any raw data.

Percent Weight Loss

The percent weight loss is simply the total weight loss divided by the initial weight:

$$\%WL = \frac{100 * T}{W}$$

Rate of Weight Loss

The rate of weight loss (kg/s) is calculated by finding the least squares straight line fit of five adjacent points on the total weight loss curve. The rate of weight loss at the center point then, is simply the slope of the line:

$$W' = \frac{N * SUM[t(i)*T(i),i=a,b] - SUM[t(i),i=a,b] * SUM[T(i),i=a,b]}{N * SUM[t(i)**2,i=a,b] - (SUM[t(i),i=a,b])**2}$$

where W' is the rate of weight loss (kg/s), T is the total weight loss (kg) at time t (s), N is the number of points fit (currently 5) and SUM is the summation function. In general (except near the end points), if I is the point of interest, then a = I - 2 and b = I + 2.

By dropping the "oldest" point and adding a new one, the slope can be found efficiently at every point.

Note that to be able to calculate the rate of weight loss, the corresponding time channel must be available.

Input	Variables	Format	Comments
HCm1	JCHAN,NPWL {,WEIGHT}, NRWL {,JTIME} X	EVALU8 (NPDI [2])	Only one of these inputs is read each time the command WT-RATE is given. JCHAN - total weight loss channel number, kg (NPDI [3]) NPWL > 0 - percent weight loss calculation to be made. One channel created. WEIGHT - initial weight of object, kg. Enter this value only if NPWL > 0. NRWL > 0 - rate of weight loss calculation to be made. One channel created. JTIME - corresponding elapsed time channel, s. Enter this value only if NRWL > 0. X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

15.14 Part H, Class C, Subpart n: Input Specified by Complex Command ZERO-TC

ZERO-TC

The subroutine finds the least squares fit of temperatures from various sized thermocouples and calculates the temperature for any other given size of thermocouple using the derived coefficients. Typically, the temperature is calculated for a zero diameter thermocouple.

The evaluated equation is of the form:

$$T(e) = A0 + A1 * D(e)$$

where T(e) is the calculated temperature for a thermocouple of diameter D(e), and A0 and A1 are the derived coefficients from the least squares fit:

$$A1 = \frac{SUM(D(i)*T(i),i=1,N) - (SUM(D(i)) * SUM(T(i)),i=1,N) / N}{SUM(D(i)**2,i=1,N) - (SUM(D(i),i=1,N))**2 / N}$$

$$A0 = \frac{SUM(T(i),i=1,N)}{N} - A1 * \frac{SUM(D(i),i=1,N)}{N}$$

where D(i) and T(i) are the thermocouple diameter and its related temperature, N

is the number of thermocouples, and SUM is the summation function. Note that at least two thermocouples must be input.

The calculated temperature is stored in a channel created by the program. This subroutine does not reduce any raw data. Any units may be used for the diameters and temperatures as long as they are consistent within a group.

Input	Variables	Format	Comments
HCn1	NGRP	open (NPDI [1])	Only one of these inputs is read each time ZDIAM is called. NGRP - number of groups of thermocouples to be fit. Prepare NGRP sets of HCn2 inputs. (NGRP channels created, one for each group.)
Input	Variables	Format	Comments
HCn2	[EVDIAM,] DIAM(1), TEMP(1),DIAM(2), TEMP(2),...,DIAM(i), TEMP(i) X 1 <= i <= 25	EVALU8 (NPDI [2])	EVDIAM - diameter for which the derived fit is evaluated (default, if omitted, is zero) DIAM - thermocouple diameter TEMP - thermocouple channel number (NPDI [3]). X = ' X' - end-of-set mark

Enter Another Command (Data Input H1)

Appendix A

Sample Set of Input Data for RAPID

To aid users in preparing input data from the execution of RAPID, a sample set of data that has been used to perform calculations on data collected by an automatic data acquisition system is presented on the following pages. A detailed description of each data input in the data set is presented to give the user an idea of the placement and function of the various data inputs used to perform calculations with RAPID. The information is divided into three columns. In column 1, the identifying data input number as indexed in this report and throughout the computer program is shown. In column 2, a detailed description of the variables read from the line of input and their values is presented. Column 3 shows the data input itself as it would be used as input for RAPID. **Note that many spaces may occur between data inputs in Column 3. These multiple blank lines are only to allow a complete description of the data set and would not be included in an input data file for RAPID**. A listing of the same data set exactly as it would look to execute RAPID is included at the end of this appendix.

Data Input	Description	Sample of Data Set Prepared for the Use of RAPID
A1	This input specifies the input parameters as INTYPE=2, INPRT=0, INPNCH=0, INSTOP=0, INERR=0, INSKIP=1, INSAVE=0, INTEST=0, and thus specifying pre-processed raw data images with skipping of some input records as specified in data input Part D, below.	2 0 0 0 0 1 0 0
A2	This input specifies the output parameters as NTEST=0, NPRT=1, NPNCH=8, NPLOT=1, NCORR=0, NERR=5, and thus specifying that the transformed data matrix should be printed and output to logical unit 8 in reduced data format. Printer plots of the transformed data matrix are to be prepared as specified in data images, Part I, below. Finally, a maximum of 5 error messages should be printed by any of the data reduction subroutines.	0 1 8 1 0 5
B1 B2	These two data images specify the title of the experiment, printed at the top of all pages of output.	FURNITURE CALORIMETER TEST #110 85.0806 FAN SPEED TEST
B3	For each instrument included in the data matrix, there must be a input of this form defining the instrument number, the instrument type, and a description of the instrument. In this sample, the	99 1TIME ELAPSED TIME (S) 80 2MARKEREVENT MARKER (V) 78 2TC THERMOCOUPLE (C) 79 2TC THERMOCOUPLE (C) 81 3RADMTRRADIOMETER #624416 (KW/SQ M) 82 2CO2 CARBON DIOXIDE CONCENTRATION #34678 SPAN 9.42% (VOL %)

	first data image specifies an instrument number of 99, instrument type of 1, and a name describing the channel as the time reading for the data set.	83 2CO CARBON MONOXIDE CONCENTRATION #34753 SPAN 1.82% (VOL %) 84 2O2 OXYGEN CONCENTRATION (VOL %) 85 2GASVELBI-DIRECTIONAL PROBE (M/S) 86 2WTLOSSTOTAL WEIGHT LOSS (KG) 87 2SMOKE SMOKE EXTINCTION COEFFICIENT
B4	A 999 in columns 78, 79 and 80 specifies the end of the list of instrument descriptions.	999
B5	For each instrument type, a set of conversion coefficients is required. For instrument types 1 and 2, the conversion is 1.0. For instrument type 3, it is 26355 -- thus specifying that all type three instruments should be multiplied by 26355.	1.0 1.0 26355.
B6	A 999 in columns 78, 79, and 80 specifies the end of the list of conversion coefficients.	999
	Since INTYPE was not equal to zero in data image A1, above, no Part C data images are required.	
D1b	Part D specifies the records to be skipped during the processing of the data recorded by the data acquisition system. Here, the first four records are to be skipped; the remainder kept and processed normally.	SKIP=(S1)4

	Part E data specify input data as recorded by the data acquisition system. They are only required for INTYPE=0 or 3 through 10. For the current data set, INTYPE=2, thus specifying reading of Part F data inputs.	
F1 / F2	Part F data are in a format generated when INSAVE and / or NPNCH are greater than zero. For INTYPE=2 (as specified in data image Part A1, above), the Part F data images would be read in the data stream at this point from logical unit LUD as specified in the main program RAPID. Part G data images are read only if parameter NCORR is non-zero. No corrections were specified in Part A1, above, thus no corrections are specified at this point.	
H1 HUa1	Part H data images specify the calculations to be performed. Any number of calculations can be performed in a single run. This first calculation designates utility command TIME. Note that comments are permitted with at least one space between the command and the comment. Channel 99 is shifted by -120 seconds and store in channel 99.	TIME 120 SECONDS TO IGNITION 99 0 0 -120.

H1	Another data image Part H1	GAS%
HBa1	designates calculations with	3
HBa2.1	basic command GAS%. Three	82 1 0 .00014 .09557 95.5 16.6299 220.467 X
HBa2.2	separate gas concentration	34678 CO2 10
HBa2.1	calculations are to be performed.	83 1 0 -.00008 .04818 46. 6.43811 185.106 X
HBa2.2	In the first calculation, channel	34753 CO 5
HBa4.1	83 (JCHAN=83) is specified as a	84 3 -.0015 20.9 X
	type 1 gas analyzer (ITYPE=1).	
	It is not included in the	
	catalogue of known analyzers	
	(IDNO=0), and thus calibration	
	coefficients and other	
	identifying information must be	
	specified (details below). The	
	zero reading for the instrument	
	is 0.00014 (ZERO=.00014). A span	
	reading of 0.09557 (SPAN=.09957)	
	at a meter reading of 95.5	
	(SPAN=95.5) is specified.	
	Calibration coefficients of	
	CA=16.6299 and CB=220.467	
	determine the conversion from	
	meter reading to gas	
	concentration for the 10 percent	
	full scale CO_2 meter, serial	
	number 34678 (SERNO=34678,	
	GAS=CO2, and RANGE=10).	
H1	A gas velocity calculation using	VELOCITY
HBb1	command VELOCITY is perform for	1
HBb2	one velocity probe (NPROBE=1).	85 49.74 +.068 3 1 78 X
	Channel 85 (JCHAN=85) is a mono-	
	directional probe (JPTYPE=3) with	
	a sensitivity of 49.74	
	(SEN=49.74). A zero reading of	
	0.068 (ZERO=+.068) is specified.	
	A single temperature channel is	

used for temperature correction
(JTMETH=1). Temperature channel
78 (JTEMP=78) is specified.

For the remaining calculations, only the data image part and input number are noted. The data input follows the same form as detailed above for each calculation. For the details of each calculation performed, the reader is referred to the descriptions of each command for the definition of every input for each command.

```
 H1              DELAY  TIME FOR PULSE TO TRAVEL DOWN EXHAUST PIPE TO INSTRUMENTS
HUe1             1
HUe2             78  79  81  82  83  84  85  87 99 9.5 X
 H1              WT-LOSS
HBf1             1
HBf2             86 22.7 X
 H1              SPECIFY
HUl1             86 X
 H1              SMOOTH
HUk1             1
HUk2             86 99 5 X
 H1              WT-RATE
HCm1             86 0 1 99 X
 H1              SPECIFY
HUl1             $2 X
 H1              COMPUTE  CHANGE RATE OF WEIGHT LOSS FROM KG/S TO G/S
HUd1             1
HUd2             $2 * 1000. X
 H1              MASS-FLOW-3
HCi1             85 0.18 78 .9 X
```

```
 H1          HEAT-RATE-2
HCe1         84 $4 1 82 1.5 13100. X
 H1          SPECIFY
HU11         $5 X
 H1          COMPUTE  CHANGE RHR FROM KW TO MW
HUd1         1
HUd2         $5 / 1000. X
 H1          INTEGRATE  COMPUTE TOTAL HEAT RELEASED (MJ)
HUh1         1
HUh2         $5 99 X
 H1          COMPUTE  RATIOS BETWEEN RHR AND RWL  AND  TOTHR AND TOTAL WT LOSS
HUd1         2
HUd2         $5 / ($2 / 1000.) X
HUd2         $7 / 86 X
 H1          SPECIFY
HU11         87 X
 H1          COMPUTE  SMOKE EXTINCTION COEFFICIENT
HUd1         1
HUd2         87 * 10. X
 H1          COMPUTE  INCREMENTAL MASS OF GASES PRODUCED
HUd1         3
HUd2         (44. / 28.97) * $4 * (1. - 1.5 * 82 * .01) * (82 * .01)  X  CO2
HUd2         (28. / 28.97) * $4 * (1. - 1.5 * 82 * .01) * (83 * .01)  X  CO
HUd2         (18. / 28.97) * $4 * (     1.5 * 82 * .01)               X  H2O
 H1          COMPUTE  MASS OF GASES PRODUCED PER MASS LOSS OF SAMPLE (INSTANTANEOUS)
HUd1         3
HUd2         $11 / ($2 / 1000.)  X
HUd2         $12 / ($2 / 1000.)  X
HUd2         $13 / ($2 / 1000.)  X
 H1          INTEGRATE
HUh1         4
HUh2         $11 99 X
HUh2         $12 99 X
HUh2         $13 99 X
HUh2         $2  99 X
```

```
 H1          COMPUTE  MASS OF GASES PRODUCED PER MASS LOSS OF SAMPLE (AVERAGE)
HUd1         3
HUd2         $17 / ($20 / 1000.) X
HUd2         $18 / ($20 / 1000.) X
HUd2         $19 / ($20 / 1000.) X
 H1          STATS
HUm1         4
HUm2         78 $23 0. 99 0. 300. X
HUm2         78 $23 0. 99 300.  600. X
HUm2         78 $23 0. 99 600. 900. X
HUm2         78 $23 0. 99 0. 900. X
```

```
H1          Command END signals the end of      END
            the set of calculations to be
            performed on the data set.

I1          Part I data images describe         PLOT 99 78 79
I2          printer plots to be prepared.       GAS TEMPERATURE IN PIPE
I3          Input for each plot consists of a    0. 1000. 0. 100.
I4          series of four images for each      TIME - S                    TEMPERATURE | DEG C
I1          X-Y plot and a variable number of   PLOT 99 81
I2          images for each profile plot.       RADIOMETER
I3          For the first plot described         0.  1000.  0.  500.
I4          here, channel 99 is plotted on      TIME - S                    HEAT FLUX | KW PER SQ METER
I1          the x axis versus channels 78 and   PLOT 99 82
I2          79 on the y axis.  Plotting         CARBON DIOXIDE CONCENTRATION
I3          limits for the x axis are            0.  1000.  0.  1.
I4          specified as 0. to 1000. and for    TIME - S                    CONCENTRATION | VOLUME PERCENT
I1          the y axis as 0. to 100. (XL=0.,
            XH=1000., YL=0., and YH=100.).
            Titles for the plot are given as
            "GAS TEMPERATURE IN PIPE" as an
            overall title, "TIME - S" as a
```

title for the x axis, and "GAS TEMPERATURE | C" as a title for the y axis. Note that any number of plots may be prepared in a single run. A final blank input line signals the end of the plotting specifications.

Listing of Input Data Set for RAPID

```
    2    0    0    0    0    1    0    0
    0    1    8    1    0    5
FURNITURE CALORIMETER TEST #110     85.0806
FAN SPEED TEST
    99 1TIME  ELAPSED TIME (S)
    80 2MARKEREVENT MARKER (V)
    78 2TC    THERMOCOUPLE (C)
    79 2TC    THERMOCOUPLE (C)
    81 3RADMTRRADIOMETER #624416 (KW/SQ M)
    82 2CO2   CARBON DIOXIDE  CONCENTRATION #34678  SPAN 9.42%   (VOL %)
    83 2CO    CARBON MONOXIDE CONCENTRATION #34753  SPAN 1.82%   (VOL %)
    84 2O2    OXYGEN          CONCENTRATION (VOL %)
    85 2GASVELBI-DIRECTIONAL PROBE (M/S)
    86 2WTLOSSTOTAL WEIGHT LOSS (KG)
    87 2SMOKE SMOKE EXTINCTION COEFFICIENT
                                                                          999
     1.0
     1.0
     26355.
                                                                          999
SKIP=(S1)4
TIME  120 SECONDS TO IGNITION
99  0  0  -120.
GAS%
3
82 1 0  .00014  .09557  95.5  16.6299  220.467 X
   34678     CO2   10
83 1 0  -.00008  .04818  46.    6.43811 185.106 X
   34753      CO    5
84 3   -.0015  20.9  X
VELOCITY
1
85  49.74  +.068  3  1  78  X
DELAY  TIME FOR PULSE TO TRAVEL DOWN EXHAUST PIPE TO INSTRUMENTS
1
78  79  81  82  83  84  85  87  99  9.5 X
WT-LOSS
1
86 22.7 X
SPECIFY
86 X
SMOOTH
1
86 99 5 X
WT-RATE
86 0 1 99 X
SPECIFY
$2 X
COMPUTE  CHANGE RATE OF WEIGHT LOSS FROM KG/S TO G/S
1
$2 * 1000. X
MASS-FLOW-3
```

```
85 0.18 78 .9 X
HEAT-RATE-2
84 $4 1 82 1.5 13100. X
SPECIFY
$5 X
COMPUTE  CHANGE RHR FROM KW TO MW
1
$5 / 1000. X
INTEGRATE  COMPUTE TOTAL HEAT RELEASED (MJ)
1
$5 99 X
COMPUTE  RATIOS BETWEEN RHR AND RWL  AND  TOTHR AND TOTAL WT LOSS
2
$5 / ($2 / 1000.) X
$7 / 86 X
SPECIFY
87 X
COMPUTE  SMOKE EXTINCTION COEFFICIENT
1
87 * 10. X
COMPUTE  INCREMENTAL MASS OF GASES PRODUCED
3
(44. / 28.97) * $4 * (1. - 1.5 * 82 * .01) * (82 * .01)  X  CO2
(28. / 28.97) * $4 * (1. - 1.5 * 82 * .01) * (83 * .01)  X  CO
(18. / 28.97) * $4 * (     1.5 * 82 * .01)               X  H2O
COMPUTE  MASS OF GASES PRODUCED PER MASS LOSS OF SAMPLE (INSTANTANEOUS)
3
$11 / ($2 / 1000.)  X
$12 / ($2 / 1000.)  X
$13 / ($2 / 1000.)  X
INTEGRATE
4
$11 99 X
$12 99 X
$13 99 X
$2  99 X
COMPUTE  MASS OF GASES PRODUCED PER MASS LOSS OF SAMPLE (AVERAGE)
3
$17 / ($20 / 1000.) X
$18 / ($20 / 1000.) X
$19 / ($20 / 1000.) X
STATS
4
78 $23 0. 99 0. 300. X
78 $23 0. 99 300.  600. X
78 $23 0. 99 600. 900. X
78 $23 0. 99 0. 900. X
RENAME
                                                                    999
END
PLOT 99 78 79
GAS TEMPERATURE IN PIPE
```

```
  0. 1000. 0. 100.
TIME - S                                    TEMPERATURE | DEG C
PLOT 99 81
RADIOMETER
 0.  1000.  0.  500.
TIME - S                                    HEAT FLUX | KW PER SQ METER
PLOT 99 82
CARBON DIOXIDE CONCENTRATION
 0.  1000.  0.  1.
TIME - S                                    CONCENTRATION | VOLUME PERCENT
PLOT 99 83
CARBON MONOXIDE CONCENTRATION
 0.  1000.  0.   0.1
TIME - S                                    CONCENTRATION | VOLUME PERCENT
PLOT 99 84
OXYGEN CONCENTRATION IN PIPE
 0.  1000.  10.  22.5
TIME - S                                    CONCENTRATION | VOLUME PERCENT
PLOT 99 85
GAS VELOCITY THROUGH PIPE
 0.  1000.  0.  25.
TIME - S                                    VELOCITY | METERS PER S
PLOT 99 86
TOTAL WEIGHT LOSS OF COMBUSTIBLES
 0.  1000.  0.  25.
TIME - S                                    WEIGHT LOSS | KG
PLOT 99 $02
RATE OF WEIGHT LOSS
 0.  1000.  -10.  90.
TIME - S                                    RATE OF WEIGHT LOSS | GRAMS PER S
PLOT 99 $05
RATE OF HEAT RELEASE THROUGH PIPE
 0. 1000. 0. 0.1
TIME - S                                    RATE OF HEAT RELEASE | MW
PLOT 99 $7
TOTAL HEAT RELEASED
0. 1000. 0. 10.
TIME - S                                    TOTAL HEAT RELEASED | MJ
PLOT 99 $8 $9
INSTANTANEOUS AND AVERAGE HEAT RELEASED PER KG OF SAMPLE BURNED
0. 1000. 0. 250.
TIME - S                                    MEGAJOULES PER KILOGRAM
PLOT 99 $14 $15 $16
MASS OF CO2, CO, AND H2O PRODUCED PER MASS OF SAMPLE BURNED (INSTANTANEOUS)
0. 1000. 0. 10.
TIME - S                                    KG PER KG
PLOT 99 $21 $22 $23
MASS OF CO2, CO, AND H2O PRODUCED PER MASS OF SAMPLE BURNED (AVERAGE)
0. 1000. 0. 10.
TIME - S                                    KG PER KG
```

Appendix B

Using RAPID on the CFR Minicomputer

This appendix provides details specifically on the use of RAPID on the CFR Perkin - Elmer 3252 Minicomputer. The process will be similar on other computers, with different operating systems commands to load and execute the programs.

Using the Program

On the 3252, RAPID exists in three versions (for three different maximum data set sizes). The program RAPID has a data set size of 100 columns by 100 rows. RAPIDB has a larger data set size of 400 by 400. A third version, RAPIDH has a data set size of 400 by 2000. To run RAPID, load one of the versions, assigned the appropriate logical units and start the program as:

```
*LOAD RAPID                                    (or RAPIDB or RAPIDH)
*AS 5,<RAPIDinputdatacardfile>
*AS 6,<RAPIDprintedoutputfile>
*AS 7,<RAPIDdatasystemdatafile>
*START
```

where <RAPIDinputdatacardfile> is the set of input data as detailed in the NBS report, <RAPIDprintedoutputfile> is the file where printed output from the program is to be written (which may, of course, be the printer PR:), and <RAPIDdatasystemdatafile> is the file of data collected by the data acquisition system. Up to three additional, optional logical units may be required depending upon the values of three variables read from the input data

set on logical unit 5 (variable INPNCH specifies a logical unit to write a file of data as recorded by the data acquisition system, INSAVE specifies a logical unit to write a file of data as recorded by the data acquisition system in a format which may be easily and quickly read in future RAPID runs, and NPNCH specifies a logical unit to write a file of the transformed data once all calculations have been performed). These logical units must be preassigned prior to entering the START command from MTM.

But, It Can Be Easier Than That

To make execution of the program easier, a number of CSS files have been created. Before describing them, it is necessary to detail a few conventions assumed in the use of the CSS files. A number of extensions for file names are assumed within the CSS files. A list follows.

.DTA	Data file containing the raw unformatted data as recorded by the data acquisition system.
.FRD	Data file containing formatted raw data prepared from the data acquisition system file (the .DTA file) by specifying INSAVE non zero on RAPID data card A1.
.CRD	Data file containing the input data for the execution of RAPID.
.RED	Data file of the transformed data written once all calculations have been preformed on the data.

.SAV File of the printed output from the execution of RAPID

A naming convention for the filenames is assumed in the CSS files as well. Each test is identified by a two character test series identification followed by up to six alphanumeric characters to uniquely identify the test within a test series. One way we have found particularly convenient is to use the date of the test in the form YYMMDD. Thus, the filename FC850806 would identify a test in the FC series (for **F**urniture **C**alorimeter) performed on August 6, 1985.

Execution of RAPID is performed in two steps. In the first, a formatted raw data file is prepared with one run of RAPID to produce a .FRD file from a .DTA file. To do this, a CSS call is entered:

*FRD <testseries>,<filename>,<printedoutput>,<versionofRAPIDtouse>

where <testseries> is the two letter designation of the series of tests to which this data set belongs, <filename> is the name of the specific test being reduced (without extensions), <printedoutput> specifies the destination of the printed output (usually PR: or C:), and <versionofRAPIDtouse> is either left blank (to use the smallest version of RAPID) or B or H to use the larger versions.

Once the FRD file is created, another CSS call can be used to create all files with extensions as outlined above:

*RAPID <filename>,<versionofRAPIDtouse>

If printed output is desired (normally the printout from the execution is left in the file <filename>.SAV), it can be routed to the printer by

*PRINT <filename>.SAV,VFC

Other Niceties to Make Your Life With RAPID Easier

One more program and CSS is available to annotate a list of RAPID input cards with created instrument numbers and locations is available. It's use has proven invaluable when creating (and especially modifying) an input data set. To use is, simply enter

*CCLIST <filename>,<printedoutput>

and you will get a two column listing with the created channels and their numbers on the left hand side and a formatted listing of the input data set on the right.

Gas Analysis Conversion Constants

A number of gas analyzers are predefined in the program and are available to

the command GAS% by number alone as detailed in Section 14.1. A listing of the predefined analyzers and their constants are shown below:

Curve	Serial Number	Make	Gas	Range	a	b
1	3351	Lira	CO2	20.0%	35.6728	232.667
2	8312	Lira	CO2	20.0%	64.0867	372.973
3	8313	Lira	CO	10.0%	22.5739	278.821
4	30760	Lira	CO	10.0%	17.8165	232.728
5	30761	Lira	CO	10.0%	17.4194	229.156
6	31497	Lira	CO2	4.0%	7.42968	239.724
7	32369	Lira	CO	2.0%	3.05138	208.020
8	100203	Beckman	CO2	0.5%	.836754	222.762
9	100203	Beckman	CO2	2.5%	1.49959	123.019
10	100203	Beckman	CO2	5.0%	6.57108	187.330
11	100203	Beckman	CO2	20.0%	14614.9	73115.0
12	100324	Beckman	CO	0.1%	22.2749	22316.4
13	100324	Beckman	CO	0.5%	.334504	128.746
14	100324	Beckman	CO	1.0%	2.76620	327.558
15	100324	Beckman	CO	5.0%	1209.37	24229.0
16	300634	Beckman	CO2	2.5%	7.52544	353.735
17	300634	Beckman	CO2	15.0%	12.2465	141.164
18	300635	Beckman	CO	1.0%	6.34414	685.198
19	300635	Beckman	CO	7.0%	5.00492	132.479
20	30759	Lira	CO	10.0%	17.1453	226.150
21	32062	Lira	CO	2.0%	2.71598	191.773
22	32371	Lira	CO2	20.0%	39.0345	249.152
23	34537	Lira	CO	15.0%	20.5896	193.337
24	34539	Lira	CO2	20.0%	29.3901	202.437
25	34677	Lira	CO2	10.0%	16.7002	221.373
26	34865	Lira	CO2	10.0%	13.7266	193.402
27	34540	Lira	CO2	20.0%	32.8684	219.574
28	34391	Lira	CO	10.0%	17.6194	230.505
29	34538	Lira	CO	15.0%	20.0793	189.892
30	32372	Lira	CO2	20.0%	29.7035	203.110

Curve	Serial Number	Make	Gas	Range	a	b
31	34678	Lira	CO2	10.0%	16.6299	220.467
32	34753	Lira	CO	5.0%	6.4381	185.106
33	103522	Beckman	CO2	2.5%	4.4600	231.000
34	31445	Lira	CO2	20.0%	37.3761	237.640
35	32098	Lira	CO	1.0%	1.2718	182.966
36	100203	Beckman	CO2	5.0%	6.3243	181.815
37	100324	Beckman	CO	1.0%	2.1355	261.877
38	101403	Beckman	CO2	5.0%	6.1889	8.972
39	101403	Beckman	CO2	20.0%	12.3116	6.180
40	101404	Beckman	CO	1.0%	2.4985	15.073
41	101404	Beckman	CO	5.0%	2.5896	5.774

Appendix C
Selected Listings from the Program

Only two routines would normally be changed by the user, the main program RAPID and block data subprogram CRVFIT. In the main program, the user may adjust the number of rows and columns in the data arrays to match the size of the data set under consideration. Subprogram CRVFIT allows the user to maintain a catalog of gas analysis equipment which can be referenced by number, without entering calibrations and identifications for the analyzers at each execution of the program.

```
      PROGRAM RAPID
C     VERSION 86.0602
C
C           XXXXXXXX  XXXXXXXX  XXXXXXXX   XXXXXX   XXXXXXXX
C           XXXX   X  X   XXXX  XXXX   X    XXXX    X   XXXX
C           XXXX   X  X   XXXX  XXXX   X    XXXX    X   XXXX
C           XXXXXXX   XXXXXXXX  XXXXXXXX    XXXX    X   XXXX
C           X   XXXX  X   XXXX  XXXX        XXXX    X   XXXX
C           X   XXXX  X   XXXX  XXXX        XXXX    X   XXXX
C           X   XXXX  X   XXXX  XXXX       XXXXXX   XXXXXXXX
C
C
C  REDUCTION ALGORITHMS FOR THE PRESENTATION OF INCREMENTAL FIRE DATA
C  -         -                  -                -                -
C  WRITTEN BY   J. NEWTON BREESE, CENTER FOR FIRE RESEARCH, NBS
C               RICHARD D. PEACOCK, CENTER FOR FIRE RESEARCH, NBS
C
C  RAPID IS A COLLECTION OF ROUTINES DESIGNED TO TRANSFORM OR REDUCE
C  DATA COLLECTED BY AUTOMATED DATA ACQUISITION SYSTEMS FROM FIRE TESTS.
C  ITS PURPOSE IS TO TRANSLATE THE COLLECTED DATA, PERFORM LINEAR AND
C  NON-LINEAR TRANSFORMATIONS ON THE DATA, AND TO PRODUCE LISTINGS AND
C  PLOTS OF THE REDUCED DATA.
C
C   RAPID COMPILE TIME PARAMETERS
C
C   NROW:      MAXIMUM NUMBER OF ROWS (SCANS) IN THE INPUT DATA
C   NCOL:      MAXIMUM NUMBER OF COLUMNS (INSTRUMENTS) TO BE PROCESSED
C   MAXPLT:    MAXIMUM NUMBER OF CURVES TO BE PLOTTED ON A SINGLE CURVE
C   MAXCNL:    MAXIMUM NUMBER OF INSTRUMENTS RECORDED BY THE DATA SYSTEM
C   LUIN:      LOGICAL UNIT FROM WHICH CARD IMAGES ARE READ
C   LUOUT:     LOGICAL UNIT TO WHICH PRINT IMAGES ARE SENT
C   LUDATA:    LOGICAL UNIT FROM WHICH TEST DATA ARE ENTERED
C
      INTEGER OUTDIM,PLTDIM
      PARAMETER (NROW=400, NCOL=400)
      PARAMETER (MAXPLT=11)
      PARAMETER (MAXCNL=200)
      PARAMETER (OUTDIM=18*MAXCNL+160)
      PARAMETER (NPTS=MAXPLT*NROW+2)
      PARAMETER (PLTDIM=2*MAXPLT)
      PARAMETER (LUIN=5,LUOUT=6,LUDATA=7)
      CHARACTER VERSN*27,NAME(NCOL)*66,IPN(PLTDIM)*6,IOUT(OUTDIM)
      CHARACTER IKSP(80),JCHN(MAXPLT)*6,KHPRT(NCOL)*3
      INTEGER ATSCAN(2,NCOL)
      DIMENSION REED(NROW,NCOL),KH(NCOL),ITYPE(NCOL),C(NCOL),ADD(NCOL)
      DIMENSION X(NROW,MAXPLT),Y(NROW,MAXPLT),XP3(NPTS),YP3(NPTS)
      DIMENSION MAXR(NCOL),ICHRS(320),MCNL(MAXCNL),IPC(PLTDIM),XR(NROW)
      DIMENSION YR(NROW),JM(PLTDIM),ISKIP(320),POWER(NCOL)
      DIMENSION IXR(NROW),IYR(NROW),RMAX(NCOL),RMIN(NCOL),RAVG(NCOL)
      EQUIVALENCE (IXR,XR),(IYR,YR)
      COMMON /ERRORS/ ICRD,ISEG
      COMMON /IO/ LUI,LUO,LUD
      EQUIVALENCE (X,XP3), (Y,YP3)
      LUI=LUIN
      LUO=LUOUT
      LUD=LUDATA
C
C   VERSN IS USED FOR IDENTIFICATION PURPOSES ONLY,
C   TO IDENTIFY THE VERSION OF RAPID IN USE
C
      VERSN='PE:3242 86.0602 (400,400)'
C  VERSION 85.1009:  1)  ADDED CODE FOR SUBROUTINE COMBIN
C                    2)  REVISED SUBROUTINE HTNCLD.
C                        DEFAULT PERCENTAGE IS NOW 15.
C                        OPTION FOR EXTRAPOLATING BOTTOM TWO
```

```
66  |C                        THERMOCOUPLES TO APPROXIMATE TEMPERATURE     |  66
67  |C                        AT FLOOR.                                    |  67
68  |C                                                                     |  68
69  |C  VERSION 85.1127:  1)  SEPARATED THE CURVE FIT INFORMATION FROM     |  69
70  |C                        SUBROUTINE GASCON TO FORM BLOCK DATA CRVFIT.  |  70
71  |C                        THIS BLOCK DATA SECTION CAN BE "CUSTOM BUILT"|  71
72  |C                        FOR ANY USERS SET OF GAS METERS.             |  72
73  |C                    2)  CHANGED NAME OF PROGRAM FROM SPEEDY TO RAPID.|  73
74  |C                                                                     |  74
75  |C  VERSION 86.0602:  1)  CHANGED INPUT FORMAT FROM OPEN FORMAT TO     |  75
76  |C                        USE OF SUBROUTINE EVALU8 TO TAKE ADVANTAGE   |  76
77  |C                        OF BEING ABLE TO USE CREATED CHANNELS AS     |  77
78  |C                        INPUT.  CHANGES MADE IN SUBROUTINES SEPRAT   |  78
79  |C                        AND PRESS.                                   |  79
80  |C                                                                     |  80
81  |      WRITE (LUO,1010) VERSN                                          |  81
82  |C   INITIALIZE ARRAYS TO PREPARE FOR DATA SET                         |  82
83  |      DO 20 I=1,NCOL                                                  |  83
84  |      KH(I)=0                                                         |  84
85  |      ITYPE(I)=0                                                      |  85
86  |      MAXR(I)=0                                                       |  86
87  |      DO 10 J=1,NROW                                                  |  87
88  |      REED(J,I)=0.                                                    |  88
89  |10    CONTINUE                                                        |  89
90  |20    CONTINUE                                                        |  90
91  |      DO 30 I=1,320                                                   |  91
92  |      ISKIP(I)=0                                                      |  92
93  |30    CONTINUE                                                        |  93
94  |      DO 40 I=1,MAXCNL                                                |  94
95  |      MCNL(I)=0                                                       |  95
96  |40    CONTINUE                                                        |  96
97  |      CALL PLOT2 (NROW;NCOL,REED,KH,ITYPE,C,ADD,NAME,X,Y,MAXPLT,IOUT, |  97
98  |     2 OUTDIM,MAXR,IPC,JM,PLTDIM,IPN,MCNL,MAXCNL,ISKIP,POWER,ICHRS,IKSP,|  98
99  |     3 XR,YR,IXR,IYR,JCHN,RMAX,RMIN,RAVG,ATSCAN,KHPRT)                |  99
100 |      WRITE (LUO,1020) VERSN                                          | 100
101 |      STOP                                                            | 101
102 |C---------------------------------------------------------------------| 102
103 |1010  FORMAT ('1  RAPID DATA REDUCTION ROUTINES    VERSION: ',A)      | 103
104 |1020  FORMAT ('1  RAPID VERSION: ',A,'    END OF DATA SET')           | 104
105 |C---------------------------------------------------------------------| 105
106 |      END                                                             | 106
```

```
      BLOCK DATA CRVFIT
C
C      XXXXXXXX  XXXXXXXX  XXXX   X  XXXXXXXX   XXXXXX   XXXXXXXX
C      X   XXXX  XXXX   X  XXXX   X  XXXX        XXXX     XXXX
C      X   XXXX  XXXX   X  XXXX   X  XXXX        XXXX     XXXX
C      X         XXXXXXX  XXXX   X  XXXXXXXX    XXXX     XXXX
C      X   XXXX  X   XXXX  XXXX   X  XXXX        XXXX     XXXX
C      X   XXXX  X   XXXX   XXXX X   XXXX        XXXX     XXXX
C      XXXXXXXX  X   XXXX    XXXX    XXXX       XXXXXX   XXXX
C
      CHARACTER SERNO(50)*8,GAS(50)*8,RANGE(50)*5
      DIMENSION CA(50),CB(50)
      COMMON /CRVIDS/ SERNO,GAS,RANGE
      COMMON /CRVFTS/ CA,CB,NINS
C
C  CURVE FIT CATALOG
C
      DATA (SERNO(I),  GAS(I),   RANGE(I),  CA(I),   CB(I),  I=1,10)
     1/   '    3351','   CO2  ', ' 20.0',  35.6728, 232.667,
     2    '    8312','   CO2  ', ' 20.0',  64.0867, 372.973,
     3    '    8313','   CO   ', ' 10.0',  22.5739, 278.821,
     4    '   30760','   CO   ', ' 10.0',  17.8165, 232.728,
     5    '   30761','   CO   ', ' 10.0',  17.4194, 229.156,
     6    '   31497','   CO2  ', '  4.0',  7.42968, 239.724,
     7    '   32369','   CO   ', '  2.0',  3.05138, 208.020,
     8    '  100203','   CO2  ', '  0.5',  .836754, 222.762,
     9    '  100203','   CO2  ', '  2.5',  1.49959, 123.019,
     *    '  100203','   CO2  ', '  5.0',  6.57108, 187.330/
      DATA (SERNO(I),  GAS(I),   RANGE(I),  CA(I),   CB(I),  I=11,20)
     1/   '  100203','   CO2  ', ' 20.0',  14614.9, 73115.0,
     2    '  100324','   CO   ', '  0.1',  22.2749, 22316.4,
     3    '  100324','   CO   ', '  0.5',  .334504, 128.746,
     4    '  100324','   CO   ', '  1.0',  2.76620, 327.558,
     5    '  100324','   CO   ', '  5.0',  1209.37, 24229.0,
     6    '  300634','   CO2  ', '  2.5',  7.52544, 353.735,
     7    '  300634','   CO2  ', ' 15.0',  12.2465, 141.164,
     8    '  300635','   CO   ', '  1.0',  6.34414, 685.198,
     9    '  300635','   CO   ', '  7.0',  5.00492, 132.479,
     *    '   30759','   CO   ', ' 10.0',  17.1453, 226.150/
      DATA (SERNO(I),  GAS(I),   RANGE(I),  CA(I),   CB(I),  I=21,30)
     1/   '   32062','   CO   ', '  2.0',  2.71598, 191.773,
     2    '   32371','   CO2  ', ' 20.0',  39.0345, 249.152,
     3    '   34537','   CO   ', ' 15.0',  20.5896, 193.337,
     4    '   34539','   CO2  ', ' 20.0',  29.3901, 202.437,
     5    '   34677','   CO2  ', ' 10.0',  16.7002, 221.373,
     6    '   34865','   CO2  ', ' 10.0',  13.7266, 193.402,
     7    '   34540','   CO2  ', ' 20.0',  32.8684, 219.574,
     8    '   34391','   CO   ', ' 10.0',  17.6194, 230.505,
     9    '   34538','   CO   ', ' 15.0',  20.0793, 189.892,
     *    '   32372','   CO2  ', ' 20.0',  29.7035, 203.892/
      DATA (SERNO(I),  GAS(I),   RANGE(I),  CA(I),   CB(I),  I=31,40)
     1   /'   34678','   CO2  ', ' 10.0',  16.6299, 220.467,
     2    '   34753','   CO   ', '  5.0',   6.4381, 185.106,
     3    '  103522','   CO2  ', '  2.5',   4.4600, 231.000,
     4    '   31445','   CO2  ', ' 20.0',  37.3761, 237.640,
     5    '   32098','   CO   ', '  1.0',   1.2718, 182.966,
     6    '  100203','   CO2  ', '  5.0',   6.3243, 181.815,
     7    '  100324','   CO   ', '  1.0',   2.1355, 261.877,
     8    '  101403','   CO2  ', '  5.0',   6.1889,   8.972,
     9    '  101403','   CO2  ', ' 20.0',  12.3116,   6.180,
     *    '  101404','   CO   ', '  1.0',   2.4985,  15.073/
      DATA (SERNO(I),  GAS(I),   RANGE(I),  CA(I),   CB(I),  I=41,41)
     1   /'  101404','   CO   ', '  5.0',   2.5896,   5.774/
      DATA NINS /41/
      END
```

NBS-114A (REV. 2-8C)

U.S. DEPT. OF COMM. **BIBLIOGRAPHIC DATA SHEET** (See instructions)	1. PUBLICATION OR REPORT NO. NBS/SP-722	2. Performing Organ. Report No.	3. Publication Date August 1986

4. TITLE AND SUBTITLE

A User's Guide for RAPID,
Reduction Algorithms for the Presentation of Incremental Fire Data

5. AUTHOR(S)

J. N. Breese and R. D. Peacock

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234
GAITHERSBURG, MD 20899

7. Contract/Grant No.

8. Type of Report & Period Covered

Final

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

Same as Item 6.

10. SUPPLEMENTARY NOTES

Library of Congress Catalog Card Number 86-600565

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

The Voluminous amount of data than can be collected by automatic data acquisition systems during large scale fire tests requires the use of a digital computer for the reduction of data. RAPID is a stand-alone program specifically designed to convert raw instrument voltages collected during such tests into meaningful units. The reduced data can also be used alone or in combinations to obtain quantities that require more than minimal data reduction. The program is written with the ability to accept data from a user defined data acquisition system, with the ability to check the correctness of data included. Through the use of input data provided by the user, the data can be converted into meaningful scientific units. The data can then be presented in tabular or printer plot form, or stored for further processing.

This user's guide provides detailed instructions for the use of the program.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Computer program; data reduction; data acquisition; fire tests

13. AVAILABILITY

☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☒ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

☐ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

195

15. Price

*U.S. GOVERNMENT PRINTING OFFICE: 1986 0-491-097/52574

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